DISLOCATIONS

AND

JOINT-FRACTURES

BY

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PREFACE

A good deal of matter that might well be looked for in a preface finds its place in this book in the introduction.

Two points, however, have not been dealt with:

First, it has occurred to me in reading the completed text that references to the literature are not very full. As has been stated elsewhere, the first draft was written, as far as might be, without reference to authorities as such, and the voluminous "literature" notes, collected later, were used for the most part for verification of fact and perspective, not for incorporation in the text. Perhaps this is not the right way to work, but a reaction from the benumbing German scholasticism in which I was trained has led me to adhere to the original plan in the main.

The second point is in regard to illustrations. There is no index-list of these, but in the general index there will be found many references to illustrations (by number) as well as to pages of the text. This is part of an attempt to make the illustrations much more integrally a *part of the text* than has been the rule in medical book-making.

Whether such a result has been accomplished, I do not know. At any rate, the attempt has been made—and made on the theory that no man can do more in book-making than to present with pen and brush what *he* knows from instruction, reading, and personal observation, in as direct a way as he can.

F. J. Cotton.

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DISLOCATIONS AND JOINT-FRACTURES

INTRODUCTION

This book was originally planned as a treatise on dislocations. On a careful survey of the subject this limitation was promptly abandoned.

Dislocations do not present themselves to us as such, but rather as *injuries to* or *near* the *joints*.

Dislocations, neatly and academically classified,—considered as of settled diagnosis and irrespective of complications,—could be considered, with all the reduction schemes thrown in, in but few pages.

Injuries to and about joints, on the other hand, constitute one of the most doubtful fields of surgery, a field strewn with wrecks,—the products of mistakes and of unavoidable difficulties, prolific in discontent and in resultant actions at law—actions based only too often on unavoidable uncertainty or error.

Curiously enough, this dangerous field has been rather inadequately surveyed.

A century ago, more or less, a peculiarly acute group of observers, mainly English, with a few Germans and French, wrote on this subject most admirably. Since then we have largely copied old data, save for the excellent work of Gurlt, of Hamilton, and later of Stimson.

A decade ago the x-ray came to our aid—and to our confusion.

It seems that the time is ripe for a summary of the subject, based on personal experience, fortified by the great mass of admirable x-ray pictures more lately produced, the data of museum specimens, and the great store of valuable operative observations placed on record in the more recent literature. Such a review must be modified by the *clinical records* of preceding generations, *but is in no way concerned with their opinions.*

We are fortunate today not only in having the x-ray as an accessory method of diagnosis, but in having, as a result of this diagnostic method and of a vast array of observations made directly at operation, a material for deductions not accessible to a previous generation. Wisdom did not begin with this generation, but we have had an unusual opportunity to learn.

It is in this spirit, then, that this book has been conceived and attempted: it is not so much an effort to "revise to date" as an attempt to state what I believe we really do *know* of the subject today, freed, as

far as may be, from the encumbering traditions of earlier days—an attempt to make a fresh start, though in no ultraradical sense.

Unavoidably such a book as is here outlined must be largely personal. In the present case the book has been nearly five years in the making, and the cases cited and the cuts shown are very largely drawn from my own experience during this time and the five years preceding, and from cases seen by me with my hospital colleagues.

No doubt many single conclusions here expressed are assailable: some may be modified as time goes on, but the attempt has been made to present a doctrine of traumatic lesions brought somewhere near the developed knowledge of the day.

Only a few of the conclusions as to treatment are personal, but many conclusions, already common or shared by many surgeons, must be acted on with caution so long as responsibility is fixed by the relatively uninformed "general practice of the profession."

Our knowledge has, however, made greater strides than many realize. There is, I think, hardly a recommendation given in these pages that is not directly drawn from my own experience, or amply based on work done by my colleagues, observed by myself.

Our opportunities in the last decade have put us in a position where the advance of the next decade must be largely in the *diffusion* of such knowledge as the profession already has at hand, in the adaptation to actual working conditions of data *already available*, and in training ourselves to a greater degree of *personal skill* in diagnosis and in both non-operative and operative treatment.

There is bound to be a broadening recognition of the fact that *each fracture is a mechanical problem in itself*, so far, at least, as reduction is concerned. The more we study fractures and luxations, the more we see how definitely they fall into series of roughly constant types; but these types are *not constant in detail*, and the ancient custom of treating a fracture with a given form of reduction, or putting it up in A.'s or B.'s splint is no longer adequate practice. Greater opportunity gives greater responsibility, and our opportunity today—or, at least, tomorrow—must involve us in the obligation of having our work tested by *results*, as well as by *intentions*.

This does not mean that results must be anatomically perfect; functional results give a much better criterion, as a rule.

No damage to any machinery, human or other, increases its efficiency, and in the human machinery we cannot replace parts. Many breaks and dislocations do damage absolutely irreparable; many do damage entirely unrecognizable at the time, and for such conditions we cannot be held responsible in any way. Imperfect results must be common; mistakes must occur, and will occur in the practice of the best, but I conceive that the day is past when we may defend ourselves

by abjectly falling back on what the eminent Dr. X. said in the last century.

Our duty is *to obtain in the given case the best result obtainable in this case, by whatever means are at hand*, often irrespective of traditional methods.

For better or for worse, we must *study* our cases of trauma, must do the best we can, and must rest on the result.

I believe that fracture results in general are better today than ever before, and that more men are competent today to treat fractures than ever before.

The general practitioner should be able, will be able, to treat most fractures. His work today is good; his work tomorrow will be better if he recognizes those fractures that *cannot* be treated by routine methods, if he studies such cases carefully, and puts them in the line of *modern*, not ancient, methods. This means that doubtful results *after* reduction of luxations or luxation-fractures must be tested by the x-ray, as a rule, and that we must not be satisfied with poor results without further attempts at betterment, by means either operative or non-operative, as may be indicated. An x-ray plate *two weeks after* the injury would obviate most instances of disaffection or of legal process in cases of fracture or luxation.

Obviously, if the point of view here given is accepted, no *book* can make any man a fracture expert:—certainly no book ever has done this, whatever the point of view.

What should be possible is to acquaint the practitioner with the types of luxation and fracture that commonly occur; to familiarize him with the points of diagnosis; to illustrate the characteristic x-ray appearances; to show, by description and illustration, just how to carry out the methods of reduction and of the application of apparatus that have proved of real value; to warn him of failures in reduction that are common, and of complications that are to be watched for; to instruct him in methods of detecting them and of remedying them, if that is possible; to outline after-treatment and prognosis, and the possibilities.

Beyond this, experience, common sense, capable and trained fingers, and, perhaps most important of all, what we call mechanical sense or ability, must help him out.

I have tried to supply as best I might such information of the sort as may be given in a book.

For this purpose it has been of advantage to have had a good deal of experience at the work, to have been able to utilize a large material of this kind of surgical cases, operative and non-operative, partly my own cases, partly cases seen with my colleagues at the Boston City Hospital, and in consultation in private practice, and to have had previous training in draftsmanship and in illustration.

So far as concerns both text and illustrations, I hold myself directly responsible. No one has even assisted in the preparation of the text. The drawings are my own; most of them were drawn for this book, and are, in the strict sense, original; a very few were sketched from drawings in articles by others. Some drawings for my articles in the journals, etc., are here used again. All retouching of photographs I have done.

There is, therefore, nothing in the plates that was not meant to be there; the direct correspondence of text and illustrations may help toward clearness.

I wish to acknowledge my great indebtedness to my colleagues of the Boston City Hospital surgical staff, one and all, for the generosity with which they have allowed me to see and use their cases, and to the X-ray department of the City Hospital for the patience with which they have taken skiagraphs and furnished prints. With few exceptions, noted in the "legends," the *x*-rays used in illustration are by the City Hospital *x*-ray department. All prints checked by numbers *on* the plate are by this department.

Dr. Wm. F. Whitney, Curator of the Warren Museum (Harvard Medical School), has greatly helped me by placing the material of the Museum at my disposal for study, and it is through his permission that I am enabled to utilize many drawings from specimens in the Museum collection.

No one has formally assisted in the work, but I feel my great obligation to the interest and coöperation of Drs. J. B. Blake and E. H. Nichols, of the late Dr. L. T. Wilson, and Drs. L. R. G. Crandon, W. C. Howe, D. Scannell, H. Binney, and many others of my colleagues, as well as to successive house-surgeons who have been most efficient and painstaking in helping me.

The Boston City Hospital is in no way committed to what is here set down, but, save for the opportunity offered by service in this institution and for the courtesy of my colleagues of the staff, this book could not have been written.

CHAPTER I

GENERALITIES

DEFINITIONS

A **dislocation** is a total displacement of one articular surface from its fellow on the opposite side of the joint. Usually such a separation involves a tearing of the capsule, and often an extrusion of the end of a bone through the tear. Damage to ligaments is almost always present, but only rarely are all ligaments torn: as a rule at least the strongest ligament (as the "Y ligament" at the hip) remains intact and determines the constant fixed position that characterizes typical luxations of each of the various types.

Subluxation is the term applied to displacements of such grade that the opposed joint surfaces are still partly in contact. The terms are not precisely used, and by long custom some lesions are classed as luxations that we know to be, in the strictest sense, only subluxations.

A **distraction** injury is one in which joint surfaces have been forcibly separated from one another (with tearing of ligaments) without other change of relation. The term is rarely used save in the description of certain vertebral injuries.

A **distortion** is a result of wrenching of a joint that has damaged ligaments, but has produced no luxation. In practice we cannot separate distortions from luxations in which the bones have snapped back into place, as occurs, for example, with "sprung" finger-joints.

Sprains are injuries that have damaged ligaments by stretching, very likely with minute areas of tearing of fibers, without actual ligament rupture.

"Spontaneous" luxations are those occurring from an apparently inadequate cause. Often they result from deformity or disease of the joint-structures. They may come from incoördinated, though vigorous, muscle contraction in cases where the joint is normal in structure.

"Congenital" luxations are those occurring without trauma in early life from original defect or from paralyses. The class is also used to cover those cases occurring from trauma at birth. Many of the "congenital" luxations are not congenital at all, but the classification is adhered to because it is impossible, in many cases, to be sure of the actual origin of the trouble.

Recurrent luxations are those in which reluxation persistently recurs from slight cause. Defective and lax healing of ligament or capsule is

the usual cause: bone damage (chipping off of the edge of a joint-surface) may give rise to this trouble.

A reluxation occurring before healing is complete is *not* a recurrent luxation, nor does the fact that the same joint gives way in a second *severe* accident constitute a chronic recurrent dislocation.

A **compound luxation** is one in which there is a wound, however caused, running from the outer air to the joint-cavity.

A **fracture** is a "solution of continuity" of a bone—a break. It may be incomplete.

Incomplete fractures may be simple cracks, running only part way through the bone.

Subperiosteal fractures* may be complete, but usually are not. The periosteum in either case is not torn or appreciably stripped up. Displacement is absent or very trifling. This form of fracture is rather common in children.

A **green-stick fracture** is an incomplete fracture of unusual form, produced by relatively slow *bending* of a bone; the bone gives way on the convex side by tearing. Often the line of fracture is a Y, opening toward the convex side of the bent bone, with one arm of the Y complete; the other arm and the stem of the Y are ragged cracks, running only part of the way to the surface; the bone may, however, give way transversely. In either case the cortical layer on the concave side is intact—merely bent. The deformity of a green-stick fracture persists, maintained by the "frazzled-out," irregular projections of the break that do not readily fit back into the corresponding depressions. They may, however, be forced back approximately where they belong, and it is almost always possible to straighten out a green-stick fracture (with a good deal of force), without breaking the cortical layer of the concave side. The old practice of completing the break deliberately must be condemned without reservation.

Green-stick fractures are common in children, but occur also in adults. Subperiosteal complete fractures, even in children, are *not* green-stick fractures.

FORMS OF FRACTURE

Fractures may be of many patterns.

Transverse or approximately transverse fractures include most breaks from slow-acting forces. An osteoclast gives a transverse fracture line. Other forces may give transverse fractures, as in Colles' fracture, fractures of the femoral neck, etc. Avulsion fractures are apt to be transverse—*e. g.*, fractures of the patella.

Oblique fractures result from obliquely acting forces, as a rule; for

* Cotton: Subperiosteal Fractures: Boston Med. and Surg. Journal, Nov. 29, 1900, p. 553.

instance, the common fractures of the lower leg from falls on the feet, in which the fall is not squarely taken, are usually oblique.

Spiral fractures are the result of torsion. The type instance is that of the humerus fracture resulting from the old test of strength, in which the weaker man's hand and arm are suddenly twisted over; the resulting fracture is always a spiral* of perfect type.

Comminuted, splintered fractures are apt to be the result of direct violence, though not necessarily so. Such fractures are apt to be compound.

Compound or **open** fractures are those in which a wound, from within or without, establishes communication between the lesion and the outer surface of the body.

"**Complex**" and "**complicated**" fractures are obsolete terms that should be forgotten.

Spontaneous fractures are those in which, from vice of development, from malnutrition, from constitutional disease, from general bone degeneration, or from local bone disease (osteomyelitis, carcinoma, bone-cyst, etc.) the bone gives way under an apparently trifling stress. Fractures from abnormal muscle contraction—in tabes dorsalis, for instance—belong on the edge of this class. Fractures from extreme, but not pathologic, muscle action are often listed as "spontaneous," but do not really belong in this class.

TERMS OF DESCRIPTION

Broadly speaking, dislocations are classified under the name of the *distal* bone (*i. e.*, a dislocation at the ankle is a dislocation of the foot, not of the tibia), and it is the displacement of the *distal* fragment that is described in a fracture (*e. g.*, a Colles' fracture with *backward displacement* means displacement of the *distal fragment* backward). Rare exceptions to this rule are made only in favor of a long-established custom in certain special lesions.

All relations and all descriptions of displacement are, as far as possible, reduced to terms of in and out, anterior, posterior, etc., with the body conceived in the anatomist's position, erect, with the palms facing forward.

SPONTANEOUS AND PATHOLOGIC LUXATIONS

Spontaneous luxations belong to either the congenital or paralytic types (*q. v.*), or depend on local disease.

Subluxations, slowly or rapidly developed, occur commonly in

*G. H. Monks (Boston Med. and Surg. Journal, 1895, cxxxii, 281; and 1896, cxxxiv, 40) has reported cases of this sort with some excellent plates of mechanism and lesion.

tuberculosis, especially at the knee; they may, however, occur with any form of arthritis.

Total luxation may occur from tuberculosis (not uncommon in hip disease), with syphilitic joints, and not very rarely in the "Charcot joints" of tabes.

Acute infective arthritis, septic or gonorrheal, may lead to luxation, not by bone-destruction, but by softening and relaxing the ligaments to such a point that the joint is displaced by muscle-pull of ordinary force.

SPONTANEOUS FRACTURES

Spontaneous fractures, strictly so defined, would be limited to erosive diseases of bone. What we actually mean by the term are fractures occurring from apparently insufficient trauma. The fractures so common in tabetics, for instance, are hardly "spontaneous": they depend on incoördinate but powerful muscle action, for, contrary to the common statement, the bones of tabetics are apt to be heavy and hard, rather than atrophic.

The fractures of the insane, common enough, may perhaps be due to defective bone-strength, but are often the result of severe enough violence inflicted by the patient himself or by others.

There are, however, certain conditions involving weakening of bone structure. Commonest is the wasting of *age*, an absorption of bony tissue in both the shaft and the spongy bone-ends, with substitution by fat. A like condition may occur as a result of long disuse or from trophic lesions—*e. g.*, in paralytic conditions.

The condition called *osteogenesis imperfecta* presents bone tissue of strength, as well as size, below the normal.

"*Osteopsathyrosis*," also a congenital condition, is characterized by the liability to fracture, the patient sometimes having fractures one after the other to a total of dozens. In both these conditions repair is substantially normal. Osteopsathyrosis is sometimes recovered from, in part at least, as the child grows up. There is no constant sign of abnormality in the bones.

All the conditions of congenital lack of strength in the bones are usually "lumped" in the one class of "*fragilitas ossium*"—a good classification, on the whole, until the pathologic study of these cases is gone into more fully.

Of *general diseases favoring fracture* we may mention *osteomalacia* (usually giving distortion rather than fracture), *scurvy*, and rickets. *Rickets* of severe grade very often gives "infractions"—incomplete fractures.*

Diabetes is said to predispose to fracture and to delay repair.

Other diseases act to favor fracture only by malnutrition.

*Infractions are breaks on the *concave* side. I have seen "infraction" in one case in a tubercular patient, in one case in a normal bone in a boy of fourteen.

Of local causes that weaken bone come first the *neoplasms*, metastatic carcinomas, sarcomas, primary or secondary, the rare myelomata, etc. Local *tubercular, syphilitic,* or *osteomyelitic* processes may favor breakage under slight force, as may a bone cyst.

Spontaneous fractures or fractures from slight violence deserve especially careful x-ray study, for early recognition of a local cause may illuminate the problem of treatment and, at worst, saves the possible necessity of humiliating explanations later on.

CONGENITAL (AND PARALYTIC) LUXATIONS

These luxations have been treated very fully in orthopedic works. In this book they are described in the text with other lesions of the particular joint affected, but a word applying to the class as a whole may not be amiss.

True congenital luxations depend on defective formation of articular ends of bone or on faulty intra-uterine positions. The types of the latter class are the knee luxation known as genu recurvatum, and the subluxations of club-foot; taken early, these cases are remediable by correction of position.

Defective formation of articular structures is not accompanied by malposition at first, and may only show itself, as so often with congenital hip luxations, after active use of the limb has begun.

Here the lesion is one of defective growth: the defect tends to increase with time, and the luxation increases. Reposition of the dislocation helps, but does not necessarily cure the condition at any age.

Dislocations of the hip, some congenital shoulder lesions, and the rare type of ankle lesion known as Volkmann's*—all these lesions have some tendency to run in family lines.

Another class of luxations depend on defects of one or another of the bones composing a joint, as in the defects of the fibula,† now interpreted as results of amniotic pressure or adhesion.

Other luxations depending on defective growth of a single bone are sometimes congenital in origin, but differ in no way from those determined by defective growth from other causes. Such a luxation of the ulna at the wrist, due to defective growth of the radius, probably congenital, is shown in Figs. 487, 488, and 489.

Some luxations, like the backward luxations of the shoulder appearing very early in life, are assumed to be the result of trauma in delivery, a trauma resulting in a splitting-off of the edge of the glenoid, for instance.

Shoulder luxations again give an instance of the paralytic type: in some, at least, of the congenital backward luxations at the shoulder

* Volkmann: Deutsche Ztschr. f. Chirurgie, 1872–73, ii, 538.
† Cotton and Chute: Trans. Amer. Orthopedic Assoc., xi, p. 316.

the displacement is due to unbalanced muscle pull in infancy, the result of paralysis, usually of obstetric origin.*

It is the same sort of condition that gives subluxation, or even total luxations, of joints not actually diseased, under the unbalanced muscle pull of infantile paralysis or syringomyelia in later life.

Practically all congenital luxations should be operated on, either to produce a restoration of the joint, or for arthrodesis, but space is here lacking to go into the operative details, for which the orthopedic text-books must be consulted.

DIAGNOSIS

So far as the *general diagnosis of luxations* goes, I am inclined to quote the words of my colleague, Dr. J. B. Blake, in a recent class lecture, to the effect that the important thing, trite as it may seem, is that "in a dislocation the head of a bone is *dis-located*"—that it is *out of its place*—not in the place which it normally occupies, where it may usually be found. This is the first sign.

Next to this *dislocation* of a given bone-head the best general sign is the *loss of motion;* fractures, as a rule, give *increased* mobility; in dislocation the bone-head is displaced, while the ligaments are only partly torn; therefore the ligaments form a passive fulcrum, the new bed of the displaced head gives a passive resistance, and *motion* is *restricted.* In luxations in which ligaments are widely torn this rule does not hold. In relation to shoulder luxations, for instance, I have seen several cases in which grave results followed the overlooking of a luxation in which there was unusually free motion immediately after the injury.

In regard to general *fracture diagnosis,* we must keep in mind that the cardinal signs of fracture are *displacement* and *mobility.* Either or both may be present; rarely there are fractures in which a simple crack across the bone gives, except for the skiagraph, no sign except local tenderness. Often enough the skiagraph helps us little, or we cannot get an *x*-ray. Then diagnosis becomes a question mainly of skill in palpation.

To deal with fractures and luxations we must first educate ourselves to recognize displacements. This means, apart from a scholastic knowledge of landmarks, that we must educate hand and eye to detect *obscure* variations from the normal. Obviously, this implies a very *thorough* knowledge of the landmarks, of bony outlines, and of relations in the *normal* body—a point often neglected. The recognition of

*R. W. Smith (Dublin Jour. Med. Soc., 1839, xv, 239), Phelps (Trans. Am. Orth. Assoc., 1896, viii, 23), Scudder (Am. Jour. Med. Sci., 1898), and Stone (Boston Med. and Surg. Journal, 1900, cxlii, 265) give a sufficient résumé of the various forms of congenital luxation at this joint.

mobility, too, is not always easy, and calls for careful education of touch.

As to crepitus, it may be said that bony crepitus *proves* fracture, whereas soft crepitus indicates injury to epiphyseal or other cartilage. Crepitus is not always easily obtainable, however, even in loose fractures, and when gotten, it tells us little or nothing in regard to *location* of the fracture,* though it proves its *presence*.

THE X-RAY AND FRACTURES †

Before the era of the x-ray we seemed to have reached about the limit of our information about fractures, and our fracture lore, based in the main on the wonderful observation of men like Astley Cooper, Dupuytren, Nélaton, Malgaigne, R. W. Smith, and Hamilton, had reached that stage of dogma where knowledge is too largely a matter of weighing the opinions of others.

Then came the x-ray, and for about a decade a great many observers have had opportunity to study fractures with the aid of a new and wonderful aid to diagnosis.

The total number of cases so studied has been enormous, and the results of study have in large measure been made available, by publication, for comparison and study. As a natural result we have learned much; our whole knowledge of fractures seems transformed, viewed, as it were, in a new illumination, and a new generation is growing up who can hardly think of fractures except in terms of the skiagraph, and are impatient with, if not neglectful of, the older means of diagnosis.

For ten years we have had good x-rays to work with—the method is no longer new. We should be able to judge now rather accurately the additions to our knowledge and skill due to the data accumulated, and to judge in what way the skiagraph may be of most use to us in our routine work.

The addition to our fund of knowledge is probably the most important service of the x-ray.

Increase of Knowledge.—Fractures occur in types—nearly constant types at that. We have, of late, been able to determine in how far these types are constant, what minor variations they show, how frequently they occur. Previously, we had only museum specimens and unconfirmed clinical diagnoses to study. Now we may have for each case a tolerably accurate diagnosis of detailed lesions.

* Crepitus may often be transmitted a long way. Crepitus in a loose hip fracture may be felt nearly as well with the hand on the ankle as with it on the hip. The transmission is in the line of continuity of bone, not, for any distance, through soft parts.

† This is reproduced from a paper by the author read before the annual meeting of the Massachusetts Medical Society, and published in the Boston Med. and Surg. Jour. of September 3, 1908, clix, 327.

Many types supposed to be rare prove common, as, for instance, comminuted Colles' fracture, fracture of the ulnar styloid, fractures and luxations of the carpus.

On the other hand, lesions once commonly diagnosed are now hardly heard of, as, for example, fracture of the acromion, intracapsular fracture of the neck of the humerus, fracture of the coronoid process at the elbow, uncomplicated dislocation of the radius at the elbow.

We have learned also the frequency with which joint fractures are found as complications of apparently typical dislocations.

There is also a whole series of joint fractures about which we knew almost nothing in the old days. Most important in this list are the elbow fractures so common in children. They used to be classified, like those of adults, on a geometric basis. Work with skiagraphs has demonstrated clearly that this class really ought to be looked on as epiphyseal injuries. T-fractures and fractures of the internal condyle occur in adults, and we used to diagnose them glibly in children as well. We have learned that they do not happen. The lesions of the humerus at the elbow in children are the supracondylar fractures, the separation of the whole epiphyseal end of the bone, separation of the epiphysis of the external condyle, forming a distinct outer half of the whole epiphyseal end, and separation of the little epiphysis of the internal epicondyle, usually entirely outside the joint. These comprise the lesions which, in fact, occur.

Moreover, we have found that the dreaded gun-stock deformity is a result of supracondylar lesions only, and has nothing to do—though this was long taught—with fracture of either condyle. These have been among the most notable, though by no means the only, instances where our knowledge has been broadened.

Our knowledge of types seems now pretty complete. We have learned what to expect and look for. But this is not all, or even the best of it, because in learning what to look for we have also learned how to look.

Personal Training.—Those who have used the *x*-ray as it should be used,—merely as one means of examination,—have vastly increased their own diagnostic powers. We have learned new signs, have come to associate certain displacements, certain limitations of motion, certain points of localized tenderness, and so on, with the lesions to which they are appropriate: have, in short, by means of the *x*-ray, greatly bettered our capacity to do without the *x*-ray. So it is in cases of carpal fracture once they were utterly unrecognized, then admitted and studied; today we know that after a fall on the palm localized tenderness over the scaphoid usually means scaphoid fracture; that localized thickening added to this, with loss of extension and radial abduction, means displacement of the broken pieces: we hardly need the *x*-ray at all. So with fractures of the radial head: formerly they

were not to be diagnosed at all; now, as a result of x-ray study, we may diagnose them without needing more than the results of palpation and the testing of the loss of pronation and supination (with flexion and extension intact) to justify diagnosis.

In this way it has been possible for men favorably situated to train themselves to a personal efficiency in fracture work a good deal beyond what was attainable even a few years ago. Every case in which the diagnosis, once made, is checked and proved or disproved definitely is worth many not so checked for purposes of education, and it is in furnishing such a "check" that the x-ray serves its second purpose—that of aiding in *personal* education.

So much for the extension of the world's fund of knowledge and our own education in skill.

Routine Use.—The question of more direct bearing perhaps is what use we are to make of the x-ray in individual cases in practice—in what cases we need it, and when and how it is to be used.

Much nonsense has been written about the necessity of a skiagraph as a preliminary to treatment of any fracture—of "criminal neglect" in failing so to use it. This is the sheerest nonsense, and I wish to be clear in disclaiming it. Very commonly such use is unnecessary and it is often impracticable.

Exceptional Fractures.—There are a few classes of cases in which skiagraphy does necessarily precede any *real* treatment. Let us see what they are in fact. In a fracture of metatarsals, by direct crushing, for example, we may perhaps be able to guess at the lesions, but can be sure of nothing; until we get the plate all we can do is to put the greatly swollen foot at rest in a comfortable position. Fractures of the scapula, some injuries about the shoulder-joint, crushing injuries of the hand and wrist, fractures of the pelvis, a few hip fractures, some injuries to ankle and tarsus, often depend on the x-ray for diagnosis, in some cases because of swelling, in some because of the essential difficulty of getting at any serviceable landmarks. In all these cases, however, simple retentive apparatus till we can get an x-ray is adequate treatment for the first one or two or few days.

The same may be said of the more obscure and atypical fractures into and about joints; until we can make our diagnosis we can rest with palliative treatment.

Where we are dealing with obscure luxations, luxations complicated with fracture, or joint fractures with much displacement, the problem is different, for these we cannot let alone. The thing to do here is to make our diagnosis as closely as may be, then reduce the dislocation or correct the displacement as best we can, and wait for the plate, recognizing (and telling the patient) that we may have to have a second reduction later. In point of fact, the first reduction so made is often adequate, and no second trial is needed.

The cases where an *accurate* diagnosis is essential to reduction of *gross* displacement are, fortunately, limited, so far as I have seen, to a few luxations with or without fracture in the tarsus and foot—a very trifling percentage of cases.

Other threatening conditions, like separation of the femoral epiphysis at the knee, Pott's fracture by inversion with great displacement, etc., can be reduced at least accurately enough to avoid the dangers of delay, even without knowledge of exact details.

From this it will appear that I am no thoroughgoing believer in the necessity of an early *x*-ray, even in the classes just cited. It is well that such early *x*-rays are not necessary, for they are often unobtainable under conditions of practice as they exist.

Routine Fractures.—Now, as to the run of fractures and luxations—the routine cases coming into our charge. As we have said, the great majority fall into perfectly well-recognized classes. Aided by the skiagraph, we have evolved more precise methods of differentiating types than we used to have.

I maintain firmly that in the great majority of cases a properly trained surgeon can make his diagnosis, so far as *practical* details go, about as well without the *x*-ray. If he has not the skill so to make a diagnosis, he is unlikely to be greatly helped by *x*-rays. Those of us who have used the *x*-rays most know best how easily one may be misled by this as by any special diagnostic method.

Today we have, most properly, skiagraphers—specialists—who cannot only take plates, but can interpret them. Personally, I doubt if a man who has to have plates interpreted by specially trained men had not better leave fractures to men of special training, for one of the services of the *x*-ray has been to raise the standard of skill that may reasonably be expected.

I do not mean to decry early taking of *x*-rays, if convenient, but wish merely to emphasize my belief that they are not a *necessary* routine. Nor do I mean that every Colles' fracture, for instance, is a specialist's job; only, if the practitioner understands how to recognize direction and grade of displacement, can reduce and can gage the perfection of his reduction, he is competent enough to do without both specialist and *x*-ray in routine cases, though he will usually want an *x*-ray for purposes of *record*.

Not all men are so competent, and the practical danger is that men who know neither diagnosis nor treatment will, with a diagnosis furnished, undertake treatment they cannot handle properly.

Moreover, leaning back on the *x*-ray makes for neglect of training in manipulation and for a progressive loss of competence in this work. This we see in house-officers in the hospitals, and it is the reason, some of us believe, why fracture work in the big hospitals hardly *averages* as good as ten years or more ago. A man who does not manipulate frac-

tures for diagnosis is not apt to manipulate well for reduction, or to be a first-rate judge of the results of his manœuvers. And, after all, the preservation of the general line, the reduction of *palpable* displacements of fragments, is what concerns us; fracture treatment is and will be far from attaining exact repositions of broken surfaces.

My belief, then, is that the routine treatment of ordinary fractures should consist of the most searching examination immediately, or, if great swelling is already present, then within a day or two—an examination best conducted under ether in most cases; that we should thus establish with all possible certainty and detail just what we are dealing with, perform any necessary reduction, and "put up" the fracture.

Importance of x-rays after Reduction.—Then, in a day or two if the patient can walk, but within two weeks in any case, save sometimes in femur fractures, we should get an x-ray. An x-ray at this time tells us not only all there is to tell as to what the lesion is, but tells us also how successfully we have dealt with it. And, best of all, it tells us this at a time when we can still remedy any defects, whether due to wrong diagnosis or to faulty treatment.

In routine hospital work I find it necessary to interfere later in three cases of bad results of treatment to one where the diagnosis was essentially at fault. This is mainly because so few fractures, relatively, fall outside the recognizable types.

Malposition recognized within a fortnight may almost always be reduced by handling—rougher handling, of course, than is needful in a fresh case. If, through misfortune or fault, the skiagraph is not taken till three weeks or more have gone by, open operation may be necessary for any needful corrections. Of this, more later. If we do interfere as a result of the x-ray review, we are in duty bound to review our amended result in the same way.

My contention that the time for the x-ray is *after*, not before, reduction is based on the following considerations:

(a) Immediate x-rays are hard to get, even in hospitals; any considerable delay in reduction means poorer reduction, as a rule.

(b) x-ray examination does not take the place of the time-honored examination in anesthesia, and this examination, properly done, with immediate replacement of fragments, usually fulfils the immediate indications.

(c) Considerations of difficulty in transportation, expense, and procrastination make it unlikely that more than one x-ray will be taken in a given routine case. This one may best be taken when it will check both diagnosis and corrected position and will help in prognosis.

Late x-rays.—Now as to late x-rays, taken to inform ourselves as to end-results. I believe they should be taken only for exceptional reasons. Nearly all cases of fracture call for an x-ray at some time, but this is not the time. In the best cases the x-ray shows abnormal

positions of bone-ends; in less good cases things always appear far worse than they are. Accurate reposition is almost never attained, except by open operation, but it will be years before the laity, including the courts, will appreciate this. What is important is the obtaining of good functional results—an entirely different matter.

The only possible service, except that of record, to be rendered by the x-ray in late cases is the explanation of defective functional results *already observed*, with a view to bettering the results by operation or otherwise.

Where this is called for, well and good! Otherwise I confess I have no interest in having end-result skiagraphs: ordinarily they will tell nothing except what, clinically, are misstatements or half-truths. Remember that the x-ray does not tell anything except the relation of the original fractured bone-ends and surfaces. It shows callus little, if at all, and gives no credit for any repair for months after such repair seems complete by other tests.

In the usual run of fractures, I believe, we will be wise to use the x-ray in practically all cases, at least for record, repeating it, if we may, but certainly using it at such period as will enable us to establish or confirm the diagnosis and to "check" our treatment. It should not be used *in place of* skilled manipulation for diagnosis or as the arbiter of end-results.

REPAIR

Repair of injuries of the skeleton differs in one respect from the repair of other tissues: in other tissues, save for the peripheral nerves, healing is essentially dependent on the formation of fibrous tissue—in the skeleton we may have, under favorable conditions, an absolute *restitutio ad integrum;* bone reproduces bone, capsular tissue reproduces itself in fibrous new-growth, and even the endothelial joint layer is reproduced.

Ideally, we may have perfect repair. In fact, such repair occurs in dislocations not uncommonly, and in fractures when there has been no malposition. In practice there is apt to be either laxness or else restriction of motion from over-repair in dislocations, and overgrowth of bone in the callus that welds together the separated fragments in fractures. Some temporary overgrowth of callus is almost always present, and extreme excess is not rare.

The conditions favoring callus formation and bone-growth are imperfectly understood,* but we may formulate the following rough rules:

The primary callus is dependent for its mass on the primary blood-clot and the cellular infiltration of the surrounding tissues.

The ossification of the primary callus proceeds in the main from the

* For factors producing *defect* of bony growth see under the caption Non-union.

inner side of the periosteum, which is stripped up, more or less extensively, as a rule.

The outer side of the periosteum seems to take no part as a starting-point of ossification—*i. e.*, it furnishes no osteoblastic cells.

Callus may *enwrap* muscles or tendons, but they are not a part of the bone-forming mass.

Irritation, mechanical or other, usually increases the size of the primary callus: infection leads to its destruction.

Callus formation *between bone-ends* and the *internal callus* arising from the marrow have a part to play later, but have little to do with bone formation in the provisional consolidation which is what we know clinically as firm union.

The merging of tissues into real bony union is a long process, and occurs usually long after the case has been discharged as cured, surgically speaking.

The "restitutio ad integrum," with restoration of the marrow cavity, etc., takes many months, or even years, and is a process that we do not ordinarily concern ourselves with.

In most cases all that concerns the practitioner in dislocations is such healing as permits joint motion without pain and without tendency to recurrence of the luxation: in fractures we seek a union sufficiently firm to permit use of the limb without danger of damage. It is surprising to learn how early in the process of repair this end is reached. In operating on certain cases, even three or four weeks after the injury, one is surprised to find it very difficult indeed to break up the fracture, and yet when the bone-ends are once exposed, the original fracture surface seems practically unchanged. It is for this reason that the x-ray is so poor a guide as to union. Many a fracture that is united solidly enough for use will show on the x-ray plate only a trace of callus, with apparently unchanged ends of fragments.

NON-UNION

Non-union usually means delayed union. I can recall but one case of my own in which union actually failed, but very many cases in which it was abnormally delayed.

We all know that there are rare cases in which *resorption* of bone takes the place of callus formation, in which union is hardly to be expected, even after repeated operative interference.*

But these are not the cases met with in ordinary practice. What we do see are the cases in which there is little or no callus formation; in which the skiagraph, or open operation, demonstrates the utter lack of change in the broken ends of bone, for better or for worse, after weeks or

* These cases show in the skiagraph conical apposed bone-ends, curiously like the eroded ends of the carbon sticks in an arc-light.

3

months—cases in which union does at length occur, but only after six months or a year, or even two years, after the receipt of the injury.

The importance of these cases lies not only in the loss of time, but also in the fact that such late union almost inevitably involves shortening and other deformity from imperfect fixation.

Even the greatest care will not wholly obviate this. Moreover, the necessary fixation tends to end in loss of joint motion, despite such massage as we can safely employ. In joint fractures or breaks near the joint there is often further limitation from excessive thickening of the capsule during the long repair process. Even cases where non-union is successfully dealt with give, therefore, very imperfect results, as a rule.

The causes alleged for non-union are legion, but our knowledge of them is really very imperfect. We know that in *multiple fractures* we may often get delayed union of *one* fracture. We know that *certain bones* tend to be slow in uniting (radius in the shaft, humerus, femur, etc.). We know that fractures *within the capsule* of joints give a large proportion of cases of delayed union or non-union, probably from the presence of synovial fluid.*

Obviously, *interposition of muscle or of tendon* structures between the broken bone-ends is a bar to union. But this is not common.† In a good many cases operated on I have found it but rarely.

Commoner is the *interposition of intact periosteum.* It seems that callus formation between the bone and the outer (not the osteoblastic) surface of the periosteum is almost *nil.* In case after case I have found this to be so, and the results of denudation of bone (stripping away such periosteum, bringing bone to bone with periosteal fragments as a *cover*) have seemed to justify my notion.

Commonly enough it is hard to be sure whether the delay in union is due to this interposition of periosteum or to the very poor position usually present in such cases.

Poor position is itself a cause of delayed union, for the bridging across

* "When a bone which forms part of a joint is fractured transversely, union seldom takes place between the fractured ends, as in the patella and olecranon, where the same effusion of blood takes place, but is lost in the cavity of the joint from which it receives vessels and becomes of a ligamentous substance. When the cervix of the os femoris is fractured, it becomes united to the capsular ligament by bands. The reason for this kind of union taking place is exactly the same as in a trephined skull. For the action of the muscles inserted into the upper part of the bone draws it upward, and those into the lower part draw it downward, and the space becomes too great for the vessels of the bone to shoot into the coagulated blood and form it into bone. This I think will hold good, though it is different from the opinion of many men." (From extracts from lectures of Sir Astley Cooper, delivered in 1793, taken from the notes of Mr. Charles Fiske, Saffron Walden, 1824, fourth edition.) Substantially this statement of Sir Astley Cooper's holds true, and the rôle played by the synovial fluid has often been lost sight of.

† In one fracture it is very common, namely, in fracture of the patella in which the expansion of tendon and the periosteum on the front of the patella are torn and drop in between the fragments.

of a wide gap takes much tissue and much time, even if there is no muscle in the way. Certain cases of slow union in femur fractures are undoubtedly due to this cause.

Sepsis delays union very notably, even if there be no dead bone.

Compound fractures, even if clean, do not unite so promptly as simple fractures of like type.

Fractures in *tabetics* commonly unite well enough, but sometimes there is delay.*

The presence of *local* bone disease is a factor. Fractures due to osteomyelitis occur usually during operative interference for removal of sequestra: they do not give non-union or even delay in union. I have seen one case of fracture due to *tubercular* bone lesion that united promptly; obviously, severe local tuberculosis or *syphilis* must delay repair. The presence of a bone-cyst favors fracture, but does not retard repair.

New-growths—*carcinoma, sarcoma*, etc.—may be the cause of the fracture and also the cause of failure of the fracture to unite. Spontaneous *sarcoma of callus* is written about, but it is likely that in these cases the neoplasm precedes the fracture.

As to general "*constitutional*" causes, it may be said, first, that *age* (apart from grave malnutrition) plays no considerable rôle. Delayed union is not so very rare, even in healthy children. The general health is not as important as it looks in this regard. Many cases occur in robust young men and women.† Even actual illness often does not interfere with bone union.

Severe wasting diseases do slow up the process of union, but not very markedly.‡ Conditions involving lack or apparent lack of bone-forming material are rare, and are not always important, for fractures in patients with *osteomalacia, fragilitas ossium*, or with *rickets* unite readily, usually with excessive callus.

Scurvy does certainly delay union and may prevent it or cause resorption of formed callus, but scurvy is a rarity today.

We are told that *syphilis* plays a part in non-union; perhaps so, but I have not seen it, and have seen many fractures in syphilitics.

* Possibly connected with the increased density of bone sometimes associated with this disease. I have seen such density act as an apparent bar to union where there was no tabes.

† I have just now under treatment three such cases of "non-union" or delayed union: one in a healthy, vigorous, outdoor man of fifty; one in a normal woman of twenty-five; and one in a man of twenty-five, six feet tall, weighing 190 pounds, lean, muscular, a fine type of man in every way. Each of these cases has been operated; in none of them was there interposition of soft parts. All now show gradual, progressing union, but only after two to five times the normal interval. Surely there is an individual predisposition in this matter, potent but unknown as to its character, serious enough to make definite prognosis as to the time of union of any fracture a bit uncertain.

‡ *Diabetes* may give delay in union.

So far as the reference of the condition to any general causes goes, we have little to help us, nor is the general "constitutional" treatment of these cases convincingly successful.

Naturally, we will do our best to maintain the patient's general health; plentiful food, fresh outdoor air, etc., probably help. Thyroid medication, administration of lime salts, etc., have proved theoretically interesting, but their practical importance has not been demonstrated. Surely they are unlikely to do any harm.

The question of fixation is certainly one of the important items in prevention and cure of delayed union. No one can doubt that constant, jarring motion may interfere with union. The often delayed results in fractures occurring in sailors aboard ship show this clearly.

Nor can we, on the other hand, deny that the results of fracture healed under partial use, without fixation (as in dogs and other animals, for instance), show efficient callus formation, though often enough this is accompanied with much deformity.

Nor is there any doubt that irritation, accomplished through moderate attempted use or through the now-forgotten acupuncture, ivory pegs, and forced manipulation of earlier days, or the neater open operations of today, with or without wiring or suturing, do contribute toward the natural effort at union.

On the whole, it seems wisest to use especial care in immobilizing fractures that show a tendency to delayed union.

Weight-bearing, so far as is consistent with such immobilization, sometimes tends to promote union, sometimes does obvious harm. There seems no way to determine this, short of actual trial *in the given case.*

So, too, with massage. It should be tried for a time (removing apparatus temporarily to permit manipulation); its continuance must rest on results, according as it serves to tighten or to loosen the insufficient union *in the given case.* Either result may follow, and persistence in obviously harmful massage is indefensible, whatever our theories may be.

As to operation, I confess I have seen no case cured by operation that I do not think would have united anyway in time, save for a few cases of interposition of muscle or tendon, but I do believe that open operation—and stapling or suturing—does greatly shorten the average convalescence without undue risk, if adequately done, and does, therefore, save not only time, but deformity and disability as well.

There is no subject related to fractures in which I am so ready to plead ignorance as in this matter of delayed union, but I believe we may safely formulate the following conclusions:

Lack of immobilization is apt to lead to "non-union." At least twice I have made deliberate and successful use of this where a permanent false joint was desirable. At least twice more I have seen cases in which the like result occurred independently of any effort on my part.

Immobilization, attempted but neutralized by jarring (as on board ship), may result in long-delayed union.

Multiple fractures often show "non-union" in one or more of the breaks. Whether this is due to an unhonored excessive draft on the body's supply of lime salts I do not know.

Apparently, fractures occurring in connection with great shock—*e. g.*, in railroad accidents—show an abnormal proportion of cases of delayed union.

Sepsis delays union.

Compound fractures unite slowly even if aseptic.

Fractures through the site of malignant disease do not unite.

Age, malnutrition, and constitutional diseases (tuberculosis, syphilis, rickets, scurvy, diabetes, etc.) may, no doubt, play a part in delayed union, but are not commonly operative as causes, even when present.

As to the scope of operative treatment, it seems that failure of union in most fractures for three or four months fully justifies operation. We may find interposition of muscle or tendon, may be able to rectify an unnecessarily poor adjustment of fragments, may be able to eliminate the interposition of periosteum, may be able to fix (by wire, kangaroo tendon, or pegs) loose fragments in or outside a joint.

At worst, we are sure to refresh broken surfaces, and this, if there is no sepsis, is in itself a powerful factor in promoting union.

Personally, I still feel that a strand of kangaroo tendon (or of silk, if need be) will give all needed fixation, as a rule.

A staple here and there may help us, but plates, screws, intramedullary splints, etc., have not yet won me to allegiance. The less foreign material the tissues have to adapt themselves to, the better.

Arbuthnot Lane's staples, strangely enough abandoned by the inventor, and the modification of them which we owe to Terry, of San Francisco, have given us a means of fixation that renders the use of silver-wire sutures almost unnecessary.

In my own operative cases I consider only three alternatives: (*a*) Denudation and reduction, with the reduction maintained by external apparatus; (*b*) fixation with sutures of kangaroo tendon, passed through periosteum or bone, as the case may call for; (*c*) staples.* Staples give the *best* fixation, since they lock the fragments in two planes instead of one. Apparently, they may be used, with proper technic, without considerable danger of sepsis.

Here and there there are fractures outside the usual rule that may better be held with a nail, or, better yet, with a drill, introduced through a separate incision and removed after ten to twenty days.

In all operated cases in which callus is originally defective the

*In cases where fixation is difficult—*e. g.*, in femur fractures—I have latterly used a four-screw fixation apparatus, which is entirely removed later.

beginning of solid union is discouragingly late, but almost certain. I cannot discover that massage particularly hastens the process, or that moderate joint motion, beginning a week after operation on the average, tends in any way to delay the process of union.

TREATMENT

As to *treatment of dislocations*, it is purely a matter, first, of reduction, with the least possible damage to soft parts, then of rest until repair is pretty well advanced, then of *careful mobilization* and use.

Reduction is to be carried out so as to give complete restoration of position, by the methods that require least force—usually this means a form of reduction that utilizes as its fulcrum the part of the capsule left intact (as the Y-ligament in the hip), but we must also bear in mind that the possibility of damage to nerves (or vessels) may guide our choice of method quite as much as ease of reduction.

As to *fractures*, we are here dealing with fractures near to the joints or involving them: our treatment concerns itself particularly with avoidance of mechanical interference with joint function and of joint stiffening. Accordingly, our aim is the *most exact reposition obtainable*, and the *earliest possible return to motion* at the joint.

There has latterly been a great change in our attitude in this regard—we no longer keep a Colles fracture up in rigid splints for six weeks, and we no longer expect stiff fingers and wrists. In short, we have learned the danger of long fixation as applied to traumatic cases.

The theory of the harmlessness of fixation, brought out by Sands in 1886, was accepted because it was approximately true in tubercular joints, but this theory, unthinkingly applied to fracture, has done vast harm. In children even in fractures long fixation does little harm. As applied to adult fractures, unprejudiced observation in any hospital on any day will show the dangers of fixation.

We have also learned, on the other hand, that the *rough* passive motion taught in still earlier days does only harm, and that any *forced* passive motion is a doubtful measure.

We have not learned fully as yet the benefits of massage, or of early active motion done by the patient himself, the hands of doctor or nurse steadying the injured part. It is not necessary to follow the frenzied lead of some of the French too closely, but there is no doubt that the trend of intelligent fracture treatment is along the lines of less prolonged and less absolute fixation, of more and earlier massage, of less passive motion, and more and earlier active motion. This is particularly true in joint fractures and those fractures occurring near joints.

One point in favor of open operations on fractures is that, with the more accurate reposition and fixation made possible by this method, we may safely begin motion a good deal earlier in most cases, and thereby

avoid stiffness from fixation and, in a measure, avoid that loss of motion which results from the filling up with callus of physiologically important fossæ long left empty (as, for instance, the coronoid and olecranon fossæ at the elbow).

MASSAGE

Massage, as applicable to fractures, consists of rubbing (effleurage), of pressure (pression méthodique), and of kneading (pétrissage). The other forms of massage proper hardly come in question here; but passive motion and active motion, with or without resistance, are often wisely carried out after a séance of massage. Broadly speaking, active motion, without resistance and with the operator's fingers fixing fragments so as to guard against displacement, is most often advisable.

Massage, as we apply it in this country, is most often a procedure for "limbering up" joints already stiffening. This is all wrong. In children such massage is usually unnecessary; in adults, it is begun too late for the best results.

Certain French surgeons begin massage immediately: the results appear to be good, and there is certainly less stasis of the circulation. We are hardly educated to this yet, and, if we were, most of us have no masseurs to whom we are ready to intrust cases at this period.

It is certain, however, that massage and guarded active and passive motion should be begun much earlier than has been the American custom.

There is a chance of imperilling reposition by such measures, and, in doubtful cases, the progress of union may be checked and such irritation may be caused as to interfere with the recovery of joint motion.

The extreme advocates of massage deny both dangers: I am positive, for I have seen both results actually happen, not once, but repeatedly

I believe in massage and believe that it should be begun rather early in most cases where fixation is simple and exact, provided we can depend on a competent masseur; but I believe the continuation of massage should be dependent upon demonstrated results, for better or for worse, in the individual case, as treatment progresses.

OPERATIVE TREATMENT

A decade ago open operations on fractures and luxations were few and far between, except for fresh compound fractures. Today such operations are so common as to pass as routine work.

There is some danger that such operating may get to be too common; already a good deal of unnecessary work is being done, particularly by

rather inexperienced men. I am not one of those who believe in indiscriminate operating on simple fractures—certainly it is not called for now, nor in the future do I expect that it will be. I do believe, however, that there is a large field of usefulness for those whose experience renders such operative work reasonably safe and certain, in order to remedy (or, still better, to prevent) most of those innumerable cases that have been a reproach to the profession—excused in the past because in the past no better results were obtainable, today no longer excusable.

The question of operation is one of judgment, necessarily based on the published records of cases, as well as on personal experience.

Throughout the text of this book references to the scope of special operative procedures will be found, with some general perspective as to the results to be obtained in the given class of cases.

There are a few injuries (such as fracture of the patella, separation of the upper epiphysis of the humerus, fracture luxations of the carpus, etc.) that *ordinarily* will do better if operated on early in *any* case; other injuries call for operation *only* if the reposition ordinarily practicable fails for some special reason; by far the most common operations, however, are those performed *some time after* an injury to avert or to remedy some condition perhaps remediable by gentler means at an earlier date.

There are few faulty repositions or faulty results that cannot be bettered by operation; on the other hand, most operations undertaken late are productive of *improved* rather than actually perfect results; perfect results belong to the earlier operations, hence an added importance of close oversight and of early decision.

As to the broad outlines of procedure, we need—

1. *Accurate diagnosis,* always aided by the x-ray (except in emergency—usually compound—cases).
2. A *definite plan* of action.
3. A clear knowledge of *anatomy*—operation in the vicinity of joints, in particular, calls for exact knowledge of vessels and nerves that may be injured.
4. Adequate skin *preparation* for at least twenty-four hours, as a rule—shaving, scrubbing, green-soap poultices, corrosive dressing, alcohol preparation, and a re-sterilization under ether.
5. *Perfect operating-room technic.*

Few operations of this class are so urgent as to justify doing them under other than the best conditions.

Methods of procedure vary endlessly with the lesion to be dealt with. A few broad outlines may be laid down:

(*a*) A *tourniquet is rarely needed* and renders identifications of vessels difficult, while it carries some chance of tourniquet paralysis.

(*b*) *Multiple incisions*, if practicable in the given case without damage, are preferable to overmuch handling through one incision.
(*c*) *Tendons* and *capsules* may be cut and sutured without damage; *muscles cannot*, though the damage from cutting them may sometimes be trivial.
(*d*) *Stripping up of periosteum* to some extent is unavoidable; but we should keep it at a minimum.
(*e*) *Bone chips* are foreign bodies; remove them.
(*f*) *Great force* in manipulation is often necessary in cases where some union has taken place; it rarely does harm.
(*g*) *Bleeding* into a joint may mean later adhesions; outside a joint it makes little difference.
(*h*) A *dead space* outside the joint fills with clot and makes bone; in the joint it remains a dead space, so far as bone formation is concerned.
(*i*) Use the *simplest* means of fixation; a strand of kangaroo tendon is usually enough; sometimes a buried nail, or a drill driven through skin and bone (and removed later), will suffice. Often the Lane staple holds everything solid. Wire sutures require much mauling of the parts to insert them, have no advantage, are apt to irritate, and are rarely advisable. If fixation by stitching periosteum is enough, let it go at that.
(*j*) *Suture periosteum* over the gap if you can.
(*k*) *Suture* any cut *capsule* if you can.
(*l*) Lay *muscle over bone surfaces* to avoid adhesion of skin to bone.
(*m*) *Do not drain*, save for unusual reasons.
(*n*) Suture skin *loosely*. This will nearly always give drainage enough.
(*o*) *Fix* the limb for a few days.
(*p*) Do not be alarmed by *serous leakage*—it is normal, and in itself does not mean infection.
(*q*) Begin *passive and active motion*, as a rule, much earlier than in non-operative cases.
(*r*) *Operations* should, as a rule, be postponed for a *week or ten days* from the date of injury: at this time clot organization has begun, and the chance of sepsis is less.

COMPOUND (OR OPEN) FRACTURES AND DISLOCATIONS

A compound fracture or dislocation is one in which there is a tear in the skin and in the soft parts beneath it, leaving a communication between the bone lesion and the outer air. Whether such a communication exists or not is of great importance with regard to the entry of

infection. Infection of traumatic bone-lesions in any other way than from the outside is so rare as to be a negligible factor.

Compound fractures are rather common, compound luxations relatively rare. The treatment of the two sorts of lesion is the same, save that in compound luxation one rarely feels justified in doing less than a thorough opening-up of the joint and free irrigation, while certain few compound fractures may be treated more conservatively.

Open bone-lesions (fractures or luxations) are produced in three ways:*

1. By direct *protrusion* of the bone from within.

2. By *tearing or crushing* of tissues caught between the bone and the ground or some other external object.

3. By *penetration* of some object from without, whether it be a bullet, a sharp stone on which the patient falls, or what not.

It is not always easy to be sure just which cause has acted. It is important sometimes to be certain, in the interest of clear judgment as to probable infection, for certain cases of class 1 may be treated by less radical methods.

Diagnosis.—Diagnosis is not always simple, for often the diagnosis of the fracture must be made by the usual methods, and we are handicapped by our care lest we soil the wound. Probing for diagnosis is *not* allowable.

Sometimes the fracture is obvious, and there is a wound—the question is whether the wound communicates with the fracture or not. Sometimes the issue of blood from the wound when the region of the fracture is pressed on will give the answer; sometimes we cannot tell until the wound is laid open. In case of doubt it is well to assume that the fracture *is* compound.

Detailed diagnosis—direction of fracture lines, etc.—may often wisely be left until we open up the wound.

Treatment.—Certain injuries of this sort are obviously hopeless. If a limb has been run over by the wheel of a car, it is, I think, never worth saving.† Not only bone and muscle are gone, but vessels and nerves have been crushed and there is little left but skin, and even that not really viable. Here our only resort is amputation at a point where tissues have not been crushed.

In other cases of crushed limbs it is obvious that, though the bones be reduced and covered over, yet the skin covering them is so crushed that it must slough. Sometimes, in such cases, if the joint be covered over by sound tissues, the bone elsewhere will take care of itself (some-

* Rarely the rupturing of an old scar over the bone or joint may suffice. This we see in refractures of the patella, for instance. Such cases are too rare to deserve a place as a separate class.

† I have seen cases when it seemed worth trying, but the trial failed. Even these cases were those in which the wheel seemed not to have passed squarely over the limb.

times exfoliating), and later plastic measures or grafting will give a useful limb.*

Nevertheless, amputation is wise in some such cases, especially in case of severe ankle injuries in which the best conceivable result (attainable only after months) is no better than an artificial limb. To save a hand or arm it is justifiable to take a longer chance, and the experienced surgeon often takes what look like hopeless chances, with a fair proportion of useful limbs saved as a reward. If we try to save the limb in these cases, scrupulous after-care is most essential. Sepsis often ruins results in such cases.

Fractures from bullet wounds must be treated according to the amount of comminution and the extent of damage to soft parts. The fractures produced by small bullets may usually be treated, like other gunshot wounds, by cleansing of the wound of entrance only. If there seems danger that particles of clothing, etc., have been carried into the wound, it is wiser to clean it out. Primary amputations for bullet injuries can seldom be justified today, and secondary amputations are but rarely called for.

Of the commoner sorts of compound fractures, there is one class the treatment of which is still in dispute, namely, those fractures in which a bone (the tibia, usually) has barely pierced the skin and then rebounded, so to speak, into the tissues. The wound is very small, with slight chance for entrance of infective material. If such a case involves no comminution of bone, no large accumulation of clot, it will usually heal under a dry aseptic dressing, without other precaution than skin disinfection. But it will not always do so: some cases are infected and do very badly.

Personally, I am apt to open up such fractures and can show better results as to sepsis than have been attained by certain house-surgeons who have been allowed to use the other method. This may be a personal matter, not one of methods. Certainly under less than excellent aseptic conditions, and in the hands of inexperienced operators, the "closed" method will show the best figures in such cases.

In most compound fractures and luxations, however, the wound is wide open, the tissues more or less soiled, and often the protruding end of a bone is ground full of dirt. Here we *must* operate.

Operation is best done immediately—after twelve hours the best cleansing may well fail of results. Delay may be justified by shock—we must balance the danger of shock against that of later sepsis in the individual case.

Thorough work demands anesthesia.

*In one such case, a compound Pott's fracture with great denudation, the skin sloughed *over* the joint, but left behind soft parts enough to protect the joint. The result was a useful joint. Under the subject of Pott's fracture will be found the story of a similar case in which the attempt failed.

The skin is first cleansed with soap and with alcohol and corrosive sublimate, care being taken *not* to scrub *toward* the wound. The wound is then wiped (*not washed* at this stage) with antiseptics, the contused wound-edges *excised*, and the wound enlarged to give free access to the lesions. All soiled or contused soft parts are snipped away. The wound is scrubbed with gauze, the bone cleaned with gauze or with a brush, or the surface chipped away with rongeur forceps until a clean surface is left. Loose bone chips are removed. Then the wound is washed with salt solution (preceded, in my own practice, with 1 : 15,000 corrosive sublimate, usually) in large amount. Then the bones are reduced, and, if need be, held by kangaroo-tendon sutures.* The soft parts and the skin are loosely sutured to allow leakage *without formal drainage.* The limb is dressed in dry gauze and put up in splints or plaster, as the indications dictate.

Following such procedure there is usually a moderate temperature, falling from day to day. Pain is apt to be slight. The wound may well be inspected after five days to a week. Much staining of dressings with old blood and a moderate continued serous ooze are to be expected. In joint cases and in fractures with much contusion this oozing may continue for a fortnight without sepsis.†

Any rise of temperature after the next day, or any increase of discomfort, is an indication for inspection of the wound.

Mild infection may be checked by wet corrosive or alcohol dressings: severer infection calls for drainage; large opening of the wound may or may not be necessary.

Sepsis of a spreading type or dangerous general infection may justify amputation. Even very sharp local sepsis is not inconsistent with preservation of a useful limb. Even a septic joint may be healed usually, and sometimes with preservation of some motion.

Gas-bacillus infection usually shows itself within two days; there are temperature, malaise, dirty-looking wound-edges exuding serum (often blood-stained), and a crackling under the skin that is characteristic. Prompt treatment is called for—either amputation or generous slashing, as the case demands or permits. Early recognized and adequately treated, such cases show a relatively small mortality.

Results.—Our notion of results in compound fractures is somewhat colored by the data of a less fortunate period, before the introduction of antisepsis. Today the mortality actually due to compound frac-

* These sutures have great tensile strength, are non-irritating, and are absorbed. Wire has no advantage, and often makes trouble. At times a staple is indicated, but never anything more. The trend of opinion today is toward later interference after the wounds have healed if position is poor, rather than the application of complicated screws, etc., at a period when the risk of sepsis is grave.

† That is, without sepsis, clinically considered: very likely there may be infection, but it does not affect the result.

tures* is not large. Primary amputations are very few, secondary amputations by no means common. Sepsis, alas! is not very rare, but usually not serious; it entails slower union and a slower recovery, with some operations for removal of small sequestra, but eventually sound healing results.

The commonest permanent ill results are deformity due to the difficulty of prolonged fixation in the presence of inflamed septic wounds, and stiffness due to the long fixation necessitated by slow union.

Such delay of union need not depend on sepsis. It is generally recognized that *clean* compound fractures unite decidedly more slowly than like lesions not compound, though the cause of this delay is not clear.

EMBOLISM

Embolism, as the term is used, means pulmonary embolism—the sudden plugging of one or more pulmonary arteries with loosened clots swept through the heart into the pulmonary circulation.

It is practically always fatal, and death is usually either instantaneous, or ushered in by only a few moments of faintness and distress.

Embolism as a complication of fractures is vastly rare. Stimson cites one case, reported by Virchow, and eight others collected by Durodié. Of these 9 cases, 1 was a fracture of the femoral neck, 1 of the femur, 7 of the leg. They occurred in from sixteen to fifty-seven days after the injury.

The causes of embolism are, first, thrombus formation; second, dislodgment of the thrombus or thrombi.

Thrombus formation may come from vein trauma, from long-continued stasis with or without trauma to the vein, and from infection. Thrombi of the smaller veins must be very common.† Thrombi of the iliac veins must certainly happen with a proportion of pelvic fractures. Almost never is there any actual sign of such thrombosis, however. I have seen typical iliac thrombosis in one case only, a fracture of the femoral neck; the thrombosis occurred about six weeks after the injury, obviously as a result of stasis.

If thrombi occur with fractures, why do we not find embolism? Probably because sudden sitting up or other brusque movement is not permitted in the treatment of injuries of thigh, hip, or pelvis until long after the usual time needed for organization and fixation of the thrombus.

* Statistics, such as those of Mumford (Boston Med and Surg. Jour., May 10, 1894), covering 300 compound fractures with 10 per cent. of deaths, necessarily include deaths from other causes than the actual fracture.

† The assumption that thrombosis is the cause of the swelling so often seen in convalescence after leg fractures seems to be without proof. To me the old theory of degenerate veins, unsupported by the now wasted muscles, seems more plausible.

FAT EMBOLISM*

Fat embolism depends on the entrance into the circulation of free fat in globules too large to pass through the capillaries. This fat may come from anywhere: certainly liver fat,† and possibly even subcutaneous fat, may enter the circulation as a result of trauma. In practice, however, large enough quantities of fat to cause trouble come from the bone-marrow, and from there only. This is evidently because we have here a fluid fat, substantially free to follow the line of least resistance.

Probably every fracture is followed by the escape of some fat into the tissues, which later finds its way into torn veins or through the lymphatics into the general blood-current. The old observation of fat in the urine of fracture cases confirms the absorption of a considerable amount of fat in certain cases, without any symptoms.‡

The many animal experiments carried out by various observers show that small amounts of fat produce no results worth considering, and that, in order to bring about a fatal result, a very large amount indeed must be set free into the circulation.§ Experimentally and clinically, it has been found that increase of pressure in the medullary cavity greatly accelerates absorption, and it seems that such absorption, with a flooding of the circulation with fat, is a factor in the sudden appearance of early symptoms.

Clinically, in order to get large amounts of fat set free, we must have fracture of a *large bone*, and this fracture must be at a point where the marrow is fatty. The red marrow of children's bones gives little fat, and von Aberle‖ has pointed out the rarity of fat embolism in children's fractures** under the age of fourteen.

A very large proportion of the cases reported and studied have been in orthopedic clinics, occurring in the course of corrective operations

* Fuchsig suggested "traumatische Lipämie" as a better name, but it has not been adopted by others. Embolism caused by fat was noted by Zenker and by Wagner in 1862. Fitz, of Boston, reported the first case in this country (1876), and the first verified case diagnosed during life was reported by Fenger, of Chicago, in 1880. Much pathologic and experimental work has been done. According to Connell, there were 246 clinical cases on record in 1905.

Excellent articles of recent date (with excellent literature references) are: Von Aberle: Ztschr. f. orthopäd. Chir., 1907, xix; F. G. Connell: Jour. Amer. Med. Assoc., 1905, 612.

† Hamilton: Brit. Med. Jour., October, 1877.

‡ Von Aberle goes so far as to consider all temperatures in aseptic fractures as due to fat embolism; this theory seems to have no particular facts behind it.

§ The amount has been stated, for animals, as three times that contained in the medulla of the femur, but this applies only as the amount necessary for lung obstruction.

‖ Von Aberle: Ztschr. f. orthopäd. Chir., 1907, Bd. xix.

** There are a number of cases on record in children, but all, I think, in children with fracture of the atrophic and fatty bones associated with old paralysis, such fractures being involved in operative measures for relief of paralytic deformities.

on the brittle, degenerate, and very fatty bones of old cases of paralysis.

In ordinary traumatic fractures fatty embolism of any grade to amount to anything is really very rare.

When it occurs, the onset of symptoms may be almost immediate, or it may be delayed for some hours or a day, or, less commonly, for several days, but it belongs to the early complications, not, like pulmonary embolism from clot, to those of convalescence.

The first symptoms are most often pulmonary—disturbed rapid breathing, pallor, and then cyanosis, slowly or rapidly deepening. Auscultation reveals the presence of lung edema, with râles over all the chest—first, in the smaller branches; in the fatal cases, râles in the trachea and the expectoration of reddish-stained froth precede the end. There is marked restlessness.

The pulse becomes small and thready. Before death, consciousness is usually clouded.

With this type of attack there is little or no rise of temperature. This is the type with purely pulmonary symptoms, not commonly met with, because, while the engorgement of lung capillaries necessarily happens first, yet it is followed by capillary infarctions of the brain, as well as of the viscera.

Accordingly we usually have symptoms on the part of the brain complicating the picture of the pulmonary involvement, or wholly overshadowing it. Essentially these symptoms are on the order of coma, rapid or slow in onset; presently pupillary reactions fail.* There is a definite rise of temperature, sometimes running to 102° or even 103° F. Sometimes there are convulsive movements, general or localized. Paralyses are rare. General convulsions with vomiting occur atypically, and usually only at the end. Cheyne-Stokes respiration is sometimes noted.

The lesions that lie back of the various symptoms seem uniform, save for degree and location. In the small arterioles and capillaries of lungs, brain, kidneys, heart, liver, etc., are minute droplets of fat, too large to pass; these drops determine localized areas of infarct in "terminal" arterioles, areas of anemic disturbance only if there is a collateral blood-supply. The clinical importance of the variously situated lesions is disputed. Many are disposed to consider even the lung symptoms as cerebral in origin. Certain it is, however, that fat emboli and infarcts are found in lungs, brain, kidneys, and heart, and that the lesions in all these organs are important.

No one has explained why the emboli, which must enter the circulation early, give such late onset of symptoms as is usual. The explanation given, of gradual accumulation of emboli, can scarcely help us unless we accept a lymphatic route for the fat. It is a fact that

* The immobile pupils may be either contracted or widely dilated.

signs of trouble appear only after an interval—very often an interval of distinct "well-being," of a number of hours, and may not show up even for a fortnight.

We know that many cases recover—how they recover is unknown. No doubt, at times, the fat passes on and is eliminated by the kidneys; in other cases collateral circulation must be established and the fat absorbed *in situ*.

Diagnosis.—In every fracture, particularly in fractures involving the marrow of the long bones in adults, there is some fat embolism. Ordinarily, it is unrecognizable clinically and is unimportant.

Even serious cases are apt to be misinterpreted, as the picture is not clean-cut. In the earlier hours it may be confused with shock or bleeding; later with inhalation pneumonia or wound sepsis. There is no pathognomonic sign. Our best guide is perhaps that of time of onset. Dennis' rule; shock, three hours; fat embolism, three days; pulmonary embolism, three weeks, is apt, if not conclusive. Septic processes are not apt to give serious symptoms as early as fat embolism, and do not give lung and brain symptoms in the beginning. Pneumonia from inhalation may give a very similar picture to that of fat embolism, and the differentiation may be impossible.

Prognosis.—The outcome is uncertain. We do not know how often embolism happens, and therefore figures are of no use*; nor can we predict the results in the given case, save on general grounds—some of the apparently severest cases get well. As a rule, the progress of the symptoms in fatal cases is pretty steady. Most of the fatal cases die within a few days.

Treatment.—Prophylactic treatment consists of avoiding unnecessary handling of the limb.

Treatment of the condition, once it has developed, is confined to heart stimulation.

*Figures of percentage of deaths from this cause, computed on the total number of fractures, vary from 1 to 2 per cent. There are no figures of the percentage of cases that have embolism and recover.

CHAPTER II

DISLOCATION OF THE LOWER JAW

Dislocations may be forward, backward, outward, inward, upward, and either unilateral or bilateral. The backward and outward luxations are possible only as accompaniments of fractures—the backward dislocation involves fracture of the skull structures behind the condyle. The outward occurs only in association with fracture of the jaw itself. Inward and upward displacements are vastly rare complications of fractures, and occur only with skull-fractures.

DISLOCATION FORWARD

This is the common form, and is often met with. Bilateral are somewhat more common than unilateral luxations. The patients are usually adults in youth or middle life. Women are more liable to this displacement than men.

The cause is either muscle action alone or a slight force applied to the already open jaw. External force acts usually through tooth extraction or through introduction of foreign bodies of large size into the mouth. Muscle action is effective in yawning, laughing, coughing, or vomiting. The external pterygoid muscle gives (with the temporal probably) the force acting to draw forward the condyle, which has already advanced (with the opening of the mouth) well up on to the *eminentia articularis*, and needs only a tear or even a relaxation of the anterior capsule to let it slip forward.

Pathology.—Naturally, there are few data, as the lesion is neither a common part-result of severe accidents nor a frequent cause of operation. There are data to show that the interarticular fibrocartilage may be torn across or torn loose and carried forward. Ordinarily, however, this cartilage is very mobile, and it does not seem likely that this tearing or any extensive tearing of the anterior capsule can be of constant occurrence, for the luxation often, once reduced, leaves very little soreness or trouble. Tearing in front, when it occurs, is said to be between the interarticular cartilage and the condyle.

The point of particular interest in the pathology of this luxation is, however, as to the cause of the difficulty in reducing it. The old theory was that the coronoid process engaged the malar bone or the zygoma in such fashion as to resist reduction. This theory is definitely disproved,

and there remain but two explanations: first, the resistance of the ligaments; second, the spasm of muscles.

According to the first, the ligaments (the external and the long internal lateral and stylomaxillary ligaments) are relaxed when the jaw is open, and tighten as attempts to reduce the dislocation are made. The trouble with this explanation is that the jaw came out under very slight force over the same track by which it will *not* return, save with the exertion of much force, although the relations of the ligaments are unchanged.

It seems much more likely that the muscles, which are in obvious

Fig. 1.—Dislocation of the jaw forward, schematic.

spasm, offer a large part of the resistance. The external pterygoid acts only to pull forward anyway, and the other muscles which normally should act to close the jaws are stretched, and their pull is exerted at a new angle. A pull from a on b (Fig. 2), with a fulcrum at c, gives powerful closure; but a pull from a' to b' with a fulcrum at c' would have no closing force and would surely drive the condyle very hard against its new bed.

It seems to me that no theory that does not admit the action of the

muscles can adequately explain the difficulties of reduction.* No doubt the elastic resistance of ligaments also plays a part.

It has also been shown that the interarticular cartilage may at times be so torn and so displaced as to constitute a real obstacle to reduction by filling the socket (Perier,† Stimson‡).

Diagnosis.—There is, of course, the history of a sudden "catch," usually following on a slight force only; then there is persistent inability to close the mouth, usually with severe pain, and more or less disturbance in speaking and in swallowing, with some dribbling of saliva.

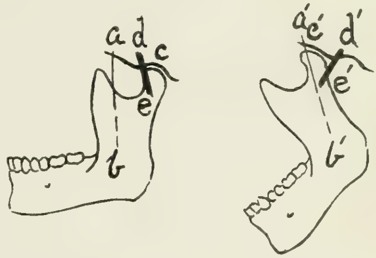


Fig. 2.—The muscle pull is on the line *a b*. With the fulcrum changed, from *c* to *c'*, the pull in line *a'–b'* tends not to favor, but to resist closure. *de* and *d'c'* show the stretched inelastic ligament.

The physical signs vary according to whether we have unilateral or bilateral luxation.

In the bilateral displacement the jaw is thrust forward—not to the right or the left. The mouth is open, and none of the teeth can be brought in contact without force. The mouth can be opened a little farther than it stands open, but an attempt to lift the jaw, to close the mouth, meets very firm resistance and is painful.

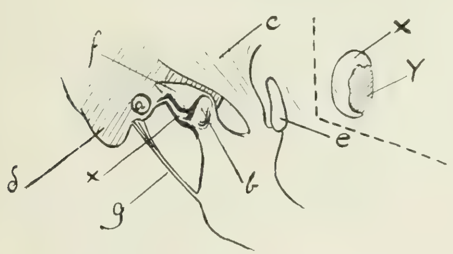


Fig. 3.—*a*, Meatus; *b*, condyle; *c*, temporal muscle; *d*, mastoid; *e*, malar bone; *f*, zygoma; *g*, stylomaxillary ligament; *x*, meniscus; *y*, denuded articular surface (seen from below in the upper right-hand figure) (after Perier's plate).

There is an increased prominence below the zygoma, and—this is the diagnostic point—there is a distinct *abnormal hollow* in front of the ear, where the resistance of the condyle (and its motion) can normally be felt (Fig. 4).

If the luxation is unilateral, the chin is swung laterally *away from* the side of injury, and the hollow in front of the ear appears on *one* side only.

* Interesting confirmation of this is given by a case in which Samter reduced a case of double luxation a year old after cutting the insertions of the masseter and the internal pterygoid, which he thought were obstructing reduction by vertical pull. Reduction on the right was easy, after clearing adhesions, but on the left reduction could be accomplished *only after more fully dividing these muscle insertions* (quoted by Bazy et Sénéchal, Revue d'orthopedie, 1906, vii, p. 353).

† Perier: Bull. Soc. de Chirurgie, 1878, p. 222 (see Fig. 3).

‡ Fract. and Dislocations, L. A. Stimson, 3d ed., p. 481.

At times this one-sidedness of the face in unilateral displacement is less obvious than would be expected (Fig. 4).

In the unilateral cases the mouth is less wide open, and the lips may be brought together after a fashion.

Absence of crepitus, of unevenness in tooth outline, of bleeding in the mouth, and of local tenderness, rule out most jaw fractures from the differential diagnosis.

Fracture of the condyle may give a somewhat similar picture, but the hollow in front of the ear is less, if any; there may be crepitus; the jaw is less fixed, and either there is no condyle palpable anywhere, or, if felt, it does not follow the jaw in its motions.

Fig. 4.—Unilateral (left) luxation. Drawn from a case of the author's. Reduction was easy.

Treatment.—Reduction follows two lines:

(*a*) *By leverage*—depression of the angle of the jaw with raising of the chin.

(*b*) *By opening the jaw to the limit and then shoving* it backward. This method, first devised to clear the supposed contact of the coronoid process on the malar bone, has been revived as a more scientific manœuver. In theory it works by relaxing ligaments; in fact, it is said to work at times when the other method fails.

It is carried out by depressing the chin as far as it will go; then, with the thumbs in or outside the mouth, thrusting the jaw backward without great force, pushing the condyle back along the way by which it came out (Fig. 5).

The first method (*a*) is called violent. In fact, however, it seems to have no ill results and is still the method of ordinary choice.

(a^1) The best way of doing it is to put the two thumbs (protected

with a twist of gauze or with heavy thumb-cots) in either side of the mouth, to the outer side of the last molar teeth. Then sharp pressure is thrown on these teeth,—down and backward,—and the operator's fingers lift the chin at the instant he slips his thumbs outward into the cheek. (See Fig. 6.) The jaw goes back with a snap. If the thumbs remain in place too long, the operator is likely to become a partizan of method *b*.

(a^2) The other mechanism of reduction by leverage is to place a bit of wood, or anything of firm texture, between the back teeth, and then shove the chin upward, or strike an upward blow on the chin. This

Fig. 5.—Reduction by opening the mouth, then shoving the jaw backward (method *b*).

seems to me crude, and, unlike (a^1), must carry with it some chance of damage to ligaments, etc.

In the run of fresh cases either of the methods is efficient. I have had experience only with a^1, and have not chanced to have it fail me.

In the description of reduction no differentiation has been made according to whether one side or both are involved. In fact, there is no difference except that the wedge in method (a^2) would, in a unilateral case, be inserted on one side only. In the other methods we may add a little extra backward shove on the injured side—that is all.

It has been recommended, in case of bilateral displacement, to reduce first one side, then the other, but the advantage is doubtful, and

records show frequent redislocation of the side already reduced on attempting to complete the job.

This dislocation may be reduced a long time after the injury. The latest recorded case of reduction without incision seems to be that reported by Donovan* at ninety-eight days. Even older cases have been reduced by open operation.

After-treatment consists merely in caution as to the use of the jaw—*i. e.*, soft food for a few days, and care not to open the mouth widely for a week or so.

A "four-tail" bandage under the chin (Fig. 13) may be a wise pre-

Fig. 6. The usual reduction by pressure down with the thumbs, pull up with the fingers (method *a*).

caution to insure this; it is, in fact, very rarely used. Most patients dispense with any apparatus or remove it.

There are cases apparently irreducible or incompletely reducible. An autopsy was performed on a case of Perier's dying of other causes with a chronic imperfect reduction of a jaw luxation. Here, as in a case operated by Stimson, tearing and displacement of the interarticular cartilage acted as the cause of difficulty in reduction: the curled-up cartilage occupied the articular space into which the condyle should have slipped. (See Fig. 3.)

Operative Treatment. In irreducible cases, or cases so inveterate

*Quoted in Amer. Jour. Med. Sci., October, 1842, p. 470.

that ordinary reduction is out of the question, cutting down on the joint for open reduction has been successfully carried out. The joint may be reached by a direct incision just below the zygoma and parallel to it. This clears the facial nerve and all but the edge of the parotid gland, and may be carried inward to expose the joint and the interarticular cartilage.

Open reduction may then be done. Samter (quoted by Bazy, *loc. cit.*) reduced a case by operation a year after the injury.

Hildebrand, of Bâle, reduced a luxation six months old by operation through a field opened by temporary resection of the zygomatic arch.

Annandale, Berard, Bazy, and Sénéchal have all done *resections* in such cases and with reported good results.

Prognosis.—It has often been stated that jaw luxations left unreduced do not reduce themselves, but do well after a time, and the patients cease to suffer any of the characteristic inconveniences.

This is true only to a degree. There is a case of R. W. Smith's on record in which, after a year, the teeth could be only "partly closed," and resection of the condyles has been done in several cases for old luxation, arguing some considerable previous distress. All that can be said is that this luxation unreduced gives a better functional result than we should expect. This is true of *all* luxations *anywhere*.

After reduction these cases give little trouble, and are usually all right in a few days. At times some soreness remains. There is a definite tendency to recurrence, which sometimes may become habitual; such recurrence seems independent of the treatment adopted, and is, after all, a rare exception.

RECURRENT DISLOCATION OF THE JAW

This is not infrequent, and may be very troublesome. Reduction offers little difficulty: frequently the patient learns to reduce the luxation himself.

Annandale has operated to relieve this condition by suturing the interarticular cartilage in place, sewing it to the capsule anteriorly, with good results. Resection of the condyle has been done in such cases with relief.

HABITUAL SUBLUXATION FORWARD (WITHOUT TRAUMA)

Certain persons develop, without any injury or other obvious cause, a subluxation in which the jaw slips farther forward than normal when the mouth is opened. This produces an unpleasant cracking during mastication.

The condition is not painful, as a rule.

There may be, for years, this habitual cracking in the joint, with an occasional catch that seems to be a subluxation. Lateral motion of the jaw may clear it, or manipulation with the hand may be necessary.

Probably these subluxations simply mean a jamming of a somewhat laxly held interarticular cartilage.

The complaint is very often annoying. It usually disappears after a time.

No treatment is of avail, seemingly. Operation seems hardly justifiable.

BACKWARD DISLOCATION OF THE JAW

This is possible only when there has been extensive smashing of the bones about the external auditory canal. There is said to be immobility, with the mouth standing open, and a loss of the prominence of

Fig. 7.—Dislocation of the jaw outward (schematic).

the condyle. Disturbance of the relation of the back teeth (the lower lying too far back) is, of course, present. There is bulging of the forward wall of the auditory canal, and there may be bleeding from the ear.

Reduction is by direct traction.

INWARD DISLOCATION

Similar smashing to the *inner* side may allow corresponding displacement inward, but not without complicating fracture of the jaw at some point of its arch.

UPWARD DISLOCATION

This, like the last, belongs to the curiosities. There is at least one case on record in which the condyle has been driven through the glenoid cavity, through the base of the skull. A fracture of the base from impact of the condyle without smashing in of the base has happened oftener. This gives no actual dislocation, of course. In either of these cases the jaw lesion is only an incident of fracture of the base of the skull.

OUTWARD DISLOCATION

This is, of necessity, rotary. The condyle comes to lie on the outer side of the zygoma, while the coronoid process is hooked under the zygoma. Such displacement is possible only if there is some fracture of the body of the jaw, as will be seen by a glance at the skull. (See Fig. 7.)

Reduction is accomplished by pressing the jaw slightly farther inward to unhook the hammer-shaped head of the condyle, and then by pushing the jaw bodily down and swinging it outward. Both coronoid process and condyle come into their natural places, and only the accompanying fracture is left to treat.

CHAPTER III

JAW FRACTURES

Fractures of the jaw through the tooth-bearing area do not concern us here, except in so far as they occur as complications. We have to do only with those fractures that counterfeit jaw luxations more or less closely—fractures at or near the angle, and those occurring behind and above this point. These are:

Fracture at or behind the angle.

Fracture of the coronoid process.

Fracture of the neck of the condyle.

Such fractures are caused by violence *directly* applied to the jaw, apparently differing in no way from the trauma usually resulting in fracture farther forward.

Not uncommonly a fracture at or behind the angle occurs *with* a fracture further forward on the same or on the opposite side. Such associated fractures are diagnosed by their own local signs. The danger is that such an anterior fracture may lead to our overlooking an associated and a more important break *behind* the angle.

FRACTURES AT OR NEAR THE ANGLE OF THE JAW

These fractures are in no way constant as to exact site or exact obliquity.

Lateral pressure gives signs of soreness, etc., and there is inability to move the jaw normally. Ordinarily, there is much thickening below the zygoma, well forward.

There is usually definite, though not great, disturbance of the "bite."

The angle of the jaw is apt to be obscured, so to speak. Ordinarily, careful palpation inside and out shows the characteristic displacements. (See Figs. 8 and 10.)

In these cases the temporal, masseter, and pterygoid muscles all tend to produce and to perpetuate the deformity. The upper fragment is pulled up and forward alongside the body of the jaw, usually to the inner side. The fragment is short and embedded in muscles, and we cannot get hold of it. (See Fig. 8.)

All the cases I have seen or known of that have been treated conservatively have done badly. The loose fragment becomes fixed in flexion and cannot be moved; the mouth cannot be opened. More-

over, owing to the bad apposition, non-union, or at least delayed union, is likely to happen and does in fact occur.

I believe, therefore, that our only effective resource in such fractures

Fig. 8.—Fracture behind the angle: the proximal fragment dragged up and inward (schematic).

Fig. 9.—Fracture of the neck of the condyle.

is open operation with wiring of the fragments. This operation can be done without opening the mouth cavity in some of the cases. In two cases of my own the results of operation were excellent, and I have heard of no ill results of such operation.

FRACTURE OF THE CORONOID PROCESS ALONE

In this lesion there is upward displacement of the fragment by the temporal muscle. Diagnosis is by palpation. This condition has been met by fixation only. I know no better method. The results are said to be good.

FRACTURE OF THE NECK OF THE JAW BELOW THE CONDYLE

This lesion is not rare, relatively speaking, and it presents some aspects suggesting luxation.

Ordinarily there is no obvious displacement of the jaw on the side

Fig. 10.—Palpation for fracture of the ramus of the jaw.

of the injury, though the "bite" is disarranged. The condyle is not palpable directly in front of the ear, but may perhaps be felt farther forward. There is not the same degree of hollowing in front of the ear that luxation presents. There is, of course, a decrease of vertical height, and the back teeth close when the front ones do not, even if the lesion is unilateral. (See Fig. 12.)

Symptoms.—The signs are: local tenderness; failure of the front teeth to close to what is apparently the old "bite" without application of force; possibility of adjusting the teeth to their normal relation by

moderate force, with a *recurrence* of the deformity on letting go; palpation of the condyle *in front* of its normal position—sometimes as a movable mass; failure of the condyle to move with the jaw; increase in mobility of the jaw *anteroposteriorly*.

Treatment.—All we can do without an incision is to bring the teeth into their normal relation and hold them there.

A simple bandage* may suffice, or we may have to have recourse to an interdental splint.

Fixation must be kept up for two or three weeks at least. During this time we would do wisely to feed the patient through a catheter inserted behind or between the teeth, or, at the worst, through the nose.

Fig. 11.—Fracture of the coronoid process (schematic).

Fig. 12.—Fracture of the neck of the condyle: usual displacement.

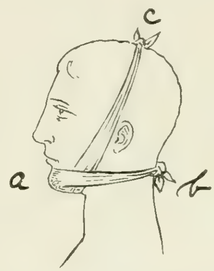


Fig. 13.—Four-tailed bandage. A pull from *a* to *c* closes the jaw and tends to hold opposing teeth in proper relation. A pull from *a* to *b* may readily increase displacement.

Results.—Results seem to be good if the displacement is corrected, though there may be some loss of mobility. Union is by bone, at least usually.

Results of neglect give an entire disarrangement of the "bite" and great loss in the range of motion.

Operation is possible, but is not encouraging; there would be little to do unless to excise the condylar fragment—a doubtful benefit.

* The usual bandage is the "four-tail." (See Fig. 13.) If this is used, we must be careful not to pull the chin back and so increase the deformity. A wedge between the upper and lower molars may, in some cases, give relief and aid reduction and retention.

CHAPTER IV

INJURIES OF THE CERVICAL SPINE

Injuries of the neck are common. They result, as a rule, from falls in which the occiput or the side of the head receives the force of the blow. Direct twisting of the neck may be a cause, or lateral flexion or extension. Even sudden muscular contraction may occasionally suffice for such injury.* Occasionally a blow directly on the back of the neck is the cause of injury.

The results are luxation or fracture, or the two combined, or a distortion† or "distraction,"‡ which involves neither fracture nor true luxation.

The results are serious, in so far as they involve—

(*a*) Damage to the cord.

(*b*) Lesion of nerves in the foramina by pressure, or damage to nerve-roots by stretching.

(*c*) Loss of normal motion, with or without deformity.

(*d*) Loss of bony support of the head.

No region of the cervical spine is free from the liability to damage. The cases that present themselves for diagnosis are mainly those of the *lower half* of the cervical spine; this is, however, not because such lesions are commoner, but because lesions of the *upper* part of the neck are so often instantaneously fatal.

When there is a crush of the cord *above the fourth cervical segment*, this cut-off, if complete, paralyzes the phrenic nerve, and death, if not actually instantaneous, is too prompt for surgical aid to come in question.

What we have to deal with clinically, therefore, are the lesions of the *upper* neck that are *incomplete*, so far as cord damage goes, and those of damage below the fourth segment, which may be fatal but are at least not promptly fatal. The whole class of injuries here involved are of great seriousness; the majority of them yield little encouragement for surgical measures.

* I have seen one case in which this was *certainly* the cause of a rotary luxation.

† A "distortion" is a twist, rotation, or lateral abduction, often involving a pull on the nerves, *not necessarily* involving bone or ligament damage. *Cf.* Courtney: Distortion of the Spine: Boston Med. and Surg. Jour., 1900, cxlii, p. 345.

‡ In "distraction" or "diastasis" component parts of the spine (bodies, intervertebral discs, articular processes, etc.) are *pulled apart, with* ligamentous damage.

Before going into description of lesions and cases it may be well to review the landmarks.

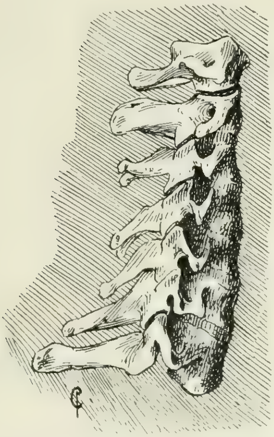


Fig. 14.—Lateral view, showing the lack of prominence of the spines of the third, fourth, and fifth vertebræ.

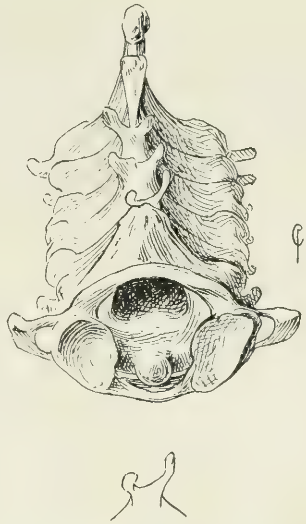


Fig. 15.—The cervical spine from above and behind, showing the irregularity of the bifid spines. The lower outline shows the contour of the third spine in this specimen.

Landmarks.—Most obvious are the spinous processes. The spinous processes of the cervical vertebræ may usually be felt pretty clearly. The "vertebra prominens," academically the seventh cervical, is, in fact, indifferently the seventh cervical or the first dorsal spine. From this point up there is a sharp loss of prominence of the spines, and in many *normal* necks there is, above the fifth or sixth, an interval corresponding to two or three spines in which nothing definite can be felt. (See Fig. 14.)

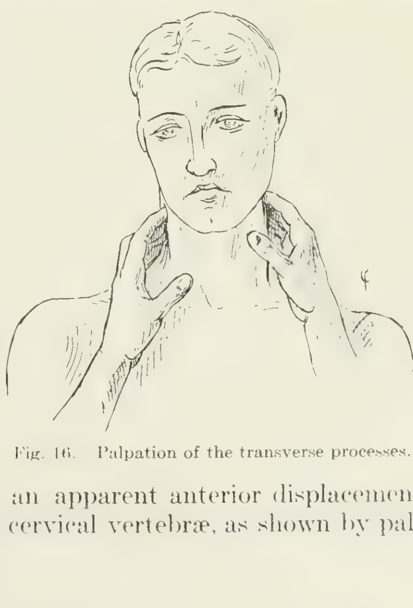


Fig. 16. Palpation of the transverse processes.

Above this we have, so to speak, a sudden reappearance of the spines. The spine of the axis is nearly always palpable—that of the atlas often is. Very little dependence can be placed on an apparent anterior displacement in the region of the fourth to sixth cervical vertebræ, as shown by palpation of the spines.

Unfortunately, we are also subject to a very considerable margin of error in regard to lateral deviation. The cervical vertebræ down to about the fifth have *bifid* spinous processes, and of these bifid processes, no one may say which side, right or left, is likely to be more prominent and more palpable. (See Fig. 15.)

On palpation of the sides of the neck we may feel the transverse processes in most individuals. These may be palpable in front or behind the sternocleidomastoid muscle; usually they are most readily felt behind it or through its substance, just behind the vessels* (Fig. 16).

So far as concerns the front of the vertebral column,—the bodies

Fig. 17.—Palpation of the anterior surfaces of the cervical vertebræ through the pharynx.

themselves,—pharyngeal examination with the finger may give very useful information. A finger inserted in the mouth may be made to reach up to the atlas, and, in the adult, down as far as the fourth intervertebral cartilage, but no further. (See Fig. 17.) In this region (first to fourth vertebræ) we must expect a certain amount of forward convexity and irregularity, and must remember that the ring of the atlas *normally* projects forward.† It is only the *sharp* deviations, caused by slipping forward of one vertebra on another, that are of any use in diagnosis.

*In relation to any extreme apparent projection of transverse processes in the *lower* part of the neck the question of cervical ribs must be borne in mind. Their occurrence is not extremely uncommon.

† See Fig. 46.

FIRST AND SECOND CERVICAL VERTEBRÆ: FRACTURES AND LUXATIONS

Because of anatomic as well as clinical reasons lesions of the upper part of the cervical spine will here be treated as a class apart, though, in consideration of the given clinical case, the distinction may not be easy.

Dislocations of Occiput on Atlas.—These are so rare as to be almost a negligible injury. The connections of atlas and skull are so secured by tough ligaments that the tendency is toward transmission of force downward to more vulnerable portions of the neck. Lesion at this level is, however, possible, and has occurred.

Dislocation of Occiput Backward on Atlas.—There are three cases fully recorded: one (that of Coste, given by Blasius*) showed forward luxation of the atlas beneath the occiput, complete on the right, incomplete on the left, and also a luxation of the atlas forward on the axis, the odontoid process being broken also. Strangely enough the paralysis present in this case was a motor paralysis only, and the patient survived the injury for five months.

The other recorded cases were instantly fatal. The cause in two cases was direct violence—a blow from behind at the level of the atlas.

Dislocations of the Atlas on the Axis.—Such dislocation is possible only when the odontoid process is slipped out from under the transverse ligament,† when it tears through this ligament, or when the odontoid itself is broken and displaced. There are a good many autopsy findings including all these possible conditions, the last being most common.

In almost all these cases the luxation is of the atlas *forward*—in some cases forward and to one side. Often there is fracture of the arches as well as of the odontoid process.

The *dislocation backward* may happen—has happened in several cases, all fatal. In one promptly fatal case (autopsied) there was also a fracture of the arch of the atlas and a fracture of the odontoid process. One would say this process *must* be broken to permit the luxation, were there not a case on record (Nichet) of a "spontaneous" luxation in which the atlas had been displaced back and to one side, jumping the intact odontoid. There is no record of such injury from trauma.

The question of *double rotary dislocation* between atlas and axis must still be left open. There is at least one probable case.

Diastasis occurs at this level with more or less displacement. I have seen one case, with obvious damage at this point, shown by tenderness and rigidity unmistakably spinal, and by a fixed forward position of the head, which showed on the x-ray plate not the expected luxation, but an apparent separation wider than normal between the first and

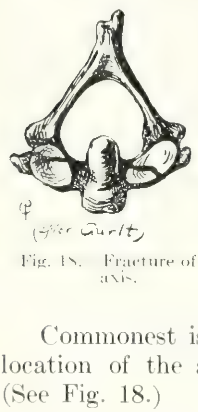
*Blasius: Vrtljhrschr. f. prakt. Heilkunde, vol. ciii, p. 65.

†Curiously enough, there is one postmortem record demonstrating the possibility of such a slipping of the odontoid out from its socket *without* complete tearing of the suspensory ligaments (Hirigoyen).

second arches, with nothing else discoverable. There were no cord or nerve-root symptoms. The patient refused the proposed fixation and bed treatment and disappeared. The injury resulted from a fall downstairs in which the back of the head was struck.

This is the mild grade of diastasis, with no more than a rocking forward of the atlas.

The severer form is that described as Malgaigne's "inclinaison," where without true luxation there is such a tipping forward (with a minimal sliding motion, of course) of head and atlas on the axis that there is pressure on the medulla between the posterior arch of the atlas and the undamaged odontoid process. If a diastasis due to ligament rupture be combined with a fracture of the odontoid, the immediate risk of compression of the cord is, of course, lessened, as atlas and odontoid slide forward *together*. Cases are on record where the displacement and the consequent compression of the medulla have been slowly progressive. Dubreuil's case showed slow gradual lowering of the chin; finally, on the seventeenth day, sudden death followed an incautious movement.



(after Gurlt)

Fig. 18. Fracture of axis.

In other cases there may be no deformity, only soreness and stiffness, without cord or nerve symptoms, and yet there may be fracture of the odontoid, even with other fractures of atlas or axis. Here the danger of sudden movement is equally present without any warning signs.

The *fractures* at this level are various and without definite type; the symptoms are not characteristic, and the x-ray helps but little in many cases.

Commonest is, perhaps the fracture of the axis, with forward dislocation of the atlas, moving with the anterior fragment of the axis. (See Fig. 18.)

Diagnosis of Lesions of the Upper Cervical Vertebrae

So few of these cases of injury to the first two cervical vertebræ survive the trauma that data for diagnosis are scanty.* This much may be said, however. Substantially all these injuries show forward displacement, if any. The deformity is in the direction of a movement of the head directly forward, or forward (with or without rotation) to one side, with the chin sometimes sunk toward or even actually resting on the chest, rotated away from the most damaged side. In contradistinction to the luxations and fractures lower down, the luxations and fractures here sometimes show not a deformity with persistent rigidity, but a simple dropping forward of the head. There is no locking as in

*The writer has seen but seven such cases, and has seen the data of four other unpublished cases: the available literature records are relatively few.

the other cases—simply a "slumping," and this seems to be true whether there is any great displacement or not.

The feeling in one's hands of some of these high luxations or fracture luxations is unique. The head simply lies loose.

There is apt to be much interference with respiration and with swallowing, partly mechanical in origin, but due also to medullary pressure in some cases.

This sort of loose lesion is certainly characteristic of atlo-axoid lesions. An occipito-atloid luxation would presumably show like looseness, with the head back and extended, but not locked.

There are, however, cases of damage between atlas and axis, including cases of odontoid fracture, where there is no laxness, no deformity, nothing at all that is characteristic; simply pain and tenderness at this level following injury, or perhaps slight abnormality of attitude or some rigidity, but nothing on which diagnosis can be made. The

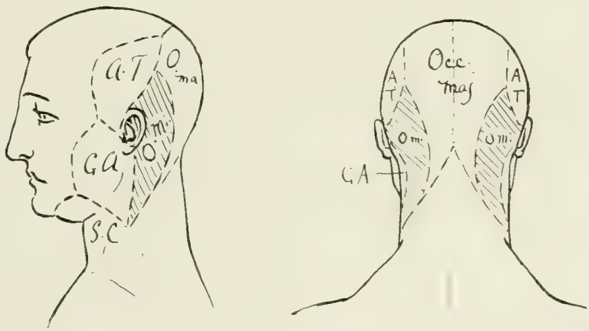


Fig. 19.—Areas of nerve-supply: Occ. maj., Occipitalis major; O. M., occipitalis minor, not uncommonly affected in atlo-axoid injury; A. T., auriculo-temporal; G. A., auricularis magnus; S. C., superficialis colli.

most we can do is to make out the level of the injury from local tenderness, for in non-fatal cases cord damage is not usually present to help show the level of the injury.

Projection of the spinous or of the transverse process of the lower vertebra backward, or on one side or the other, or projection of the body of either vertebra felt in the pharynx, are of avail, if positive, but the lack of such evidence proves nothing. A sudden unguarded movement has caused a slipping of a fractured but undisplaced odontoid, and instant death where, a moment before, there was *no* sign to point to such injury. There are several such cases.

Skiagraphs may help in showing injuries in this region, but are quite as apt not to show much of anything. Good plates of the upper neck are very hard to get, and often hard to interpret if obtained.

Anesthesia or paresthesia about the base of the skull behind (over parts not struck) suggests nerve injury by compression (occipital nerve,

rising from the second segment), and is apt to result from vertebral fracture. This sign is relatively common. (See Fig. 19.)

The importance of palpation through the pharynx seems to me to have been greatly exaggerated. There are bony prominences enough in the central line shown in bone specimens to be confusing, and when we add to these the exaggeration of prominences due to soft parts intervening, the difficulties of examination, the possible intervention of osteo-arthritic changes, etc., it is obvious that data so obtained must be judged conservatively. Nor does palpation from outside help us much.

What we have to go on in practice is the following:

(*a*) Rigidity of the neck, or abnormal position, usually in flexion, or looseness of the relaxed neck.
(*b*) Local tenderness.
(*c*) Abnormal bony prominences.
(*d*) Signs of damage to the cervical nerves.*
(*e*) *x*-ray evidence.

The only safe way is to treat all doubtful cases as actual spine lesions.

TREATMENT OF LESIONS OF UPPER CERVICAL SPINE

The question of diagnosis is subordinate, for detailed diagnosis of the bone lesion is, fortunately, not essential.

Most cases come to postmortem diagnosis only. Of the more fortunate, we have two classes: those with and those without sufficient displacement to give compression of the cord. If there are any considerable cord symptoms, it is fair to assume that they are from existing persistent pressure, and the problem is one of instant relief of this pressure.†

As a rule, the direction of displacement will be obvious—if it is not, it is pretty safe to assume that we have a forward displacement. Reduction will, of course, be in the direction of reversing this displacement.

Delay for further diagnosis is almost certainly fatal in such cases. Reduction by extension and gentle backward traction, controlled, if practicable, by manipulation with a finger in the pharynx, is the only worthy surgical treatment.

The patient may possibly die on our hands: this is the risk we take. Fortunately, the risk is small. So far as I know the much-quoted case of Petit-Radel, and one of Boyer's,‡ are the only ones recorded in which

*Damage to the cord does not greatly help in locating the *level* of the injury in these cases, for they show only *incomplete* cord lesion, as noted above.

†At this level we do not have to reckon with the cases (common at lower levels) of total cord damage, done and irremediable, without any present pressure from bone. Such extensive damage of the upper segments means instant death; lesser damage calls for active treatment.

‡Quoted by Blasius, *loc. cit.*

such correction of the lesion resulted in death. Where no risk is taken, death in such cases is almost certain.

After reduction, the obvious treatment is firm fixation, and in these cases this should take the form of—first, sand-bag fixation, with the neck supported, the head slightly extended; then, if the patient passes by the stage of probable lung complications, a plaster-of-Paris jacket (including head, neck, and upper chest) is to be worn for long enough to insure against redisplacement. (See Figs. 20 and 21.) Probably six weeks of such fixation will be enough.* The plaster-of-Paris apparatus is followed by a "Thomas" collar that steadies and supports the head and limits motion. The classic "Thomas collar" may serve;

Fig. 20.

Fig. 21

Figs. 20, 21.—Plaster cuirass. Same case as Figs. 27 and 28.

better yet is the pasteboard collar, shown in Figs. 22 to 25, worn for many weeks or even months.

Traction on the neck applied to the head is often a wise measure, helping fixation at least (Fig. 26).

* There is a case on record (Parker, quoted by Hamilton, Fractures and Dislocations, third edition, p. 161) in which fatal displacement occurred five months after injury. There was here a tearing of the occipito-axoid ligaments, as well as odontoid fracture.

This case had had no cord symptoms, but had obvious bony displacement and had had much pain.

It is true that the odontoid unites by fibrous tissue only, but I do not believe that there is ordinarily any grave risk of displacement if there is no lameness after a month or two of adequate fixation.

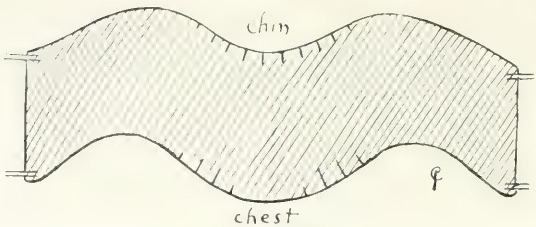


Fig. 22.—Thomas collar of "press board" cardboard. Usual pattern.

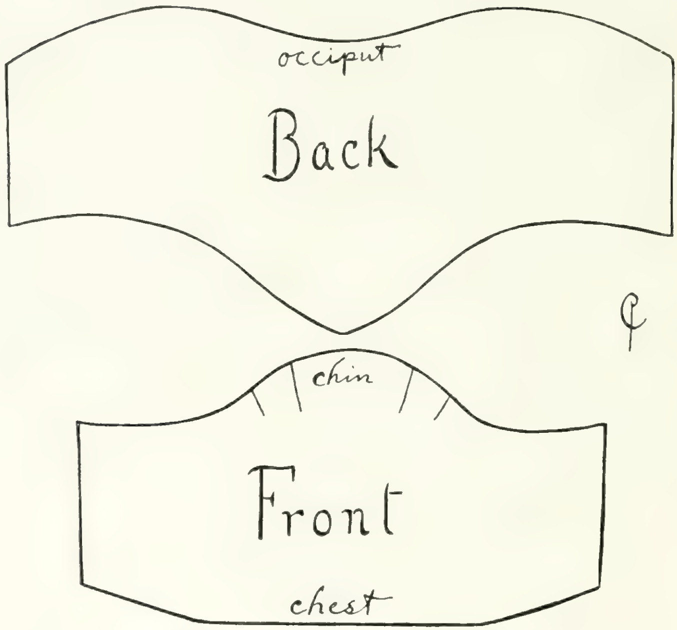


Fig. 23.—Two-piece Thomas collar. Good pattern.

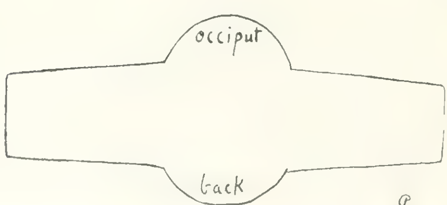


Fig. 24.—Common pattern of collar. Gives little support against flexion, but is a very comfortable pattern.

Where there has been no definite displacement and no cord damage, reduction does not come in question. Bed rest with sand-bag fixation is indicated for ten days at least; following this the collar, carefully fitted, should suffice in a tractable patient; it should be worn four weeks at least. In cases of this class we have no indication for any operative interference. Even the existence of *slight* bone displacement does not call for reduction unless there be damage to the cord, but any considerable displacement would indicate that the support had better be worn longer for safety.

In cases where damage to the cord is present, but seems slight, the matter is debatable. On the whole, the recorded cases rather suggest a leaning toward interference and reduction where the question is open,

Fig. 25. Shows the collar (made after the pattern of Fig. 24) applied.

on account of the not infrequent occurrence of progressive meningeal and cord damage in this class of cases. Anything that is done should be done promptly. Each case must be judged by itself. Personally, I should hesitate to manipulate a case of lesion *at this level*, simply because of *partial* paralysis of limited extent, unless I could form a pretty clear idea of the bone lesion. The cases personally observed have shown definite improvement (usually total) under simple fixation. It is often good surgery to "let well enough alone."

It is probably safe to formulate the following rough practical rules:

1. Cases with *cutting* of the cord are *dead.*
2. Cases with pressure on the cord will die presumably if not re-

lieved; the treatment is to take chances on a reduction by traction, extension, and *backward* replacement; then fixation. If signs of cord pressure are slight, the question of replacement is debatable.

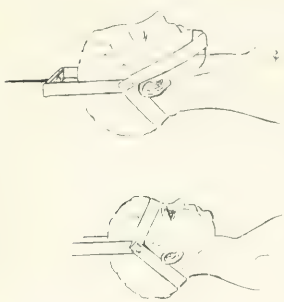


Fig. 26.—Two methods of applying traction to the head for neck extension. The method shown below can only rarely be applied to the *adult* head. With either method the *head* of the bed must be raised.

3. Cases without paralyses should be fixed; sand-bags should suffice at first; moderate extension without traction is desirable. Later, fixation is by plaster and the modified Thomas collar.

Judging from all the recorded cases it is safe to say that prompt treatment by reduction along these lines will save some cases; delay for more accurate diagnosis will show a worse percentage, both as to early deaths and as to paralysis.

Open operation—laminectomy—seems to show no encouraging results in this class of *high* lesions.

Prognosis in Lesions of the Upper Cervical Spine

The prognosis in general is bad. Many cases die instantly. Many others die within thirty-six to seventy-two hours as a result of damage to the medulla. Hyperpyrexia occurs up to 110° F. or higher; the pulse is high, and respiratory failure is added to by the distinct tendency to (vasomotor) lung edema in this class of injuries, which is often the direct cause of death.* If there is extensive paralysis, with consequent loss of action of abdominal and thoracic muscles, the distention of the abdomen encroaching on the chest capacity, with a respiratory movement confined to the diaphragm, adds a grave complication.

There is also a possibility in these cases of suppurative spinal meningitis, hard to explain, but apparently undebatable in the face of recorded cases. Other complications are rare.† The considerable chance of

*J. L., aged fourteen, seen by the writer August 12, 1907. Had fallen from a train platform shortly previous. Was in shock, dazed, but rational enough. Showed marked cyanosis, rapid and labored respiration, lungs full of coarse bubbling râles throughout. There was a wound over the occiput, but no signs of cerebral damage save for slight internal strabismus. The neck showed characteristic flaccidity, without great pain. The case was seen for me by Drs. Lund and Scannell, and by Dr. J. J. Thomas of the nerve department, who concurred in the diagnosis of high cervical lesion (loose) with medullary damage and vasomotor lung symptoms. For a time his color improved, and the labored respiration and the lung edema improved, but after three hours the edema increased, with the frothing-up of thin, bloody, mucoserous discharge. Temperature and pulse rose; he became unconscious, and died about four hours after the first examination.

†There is one case on record of tearing of both the vertebral artery and the vein (Blasius).

sudden displacement in certain cases, particularly in those of fracture of the odontoid, is to be remembered.*

Prognosis must, therefore, be guarded always, and treatment must be conservative even in the mildest cases. On the other hand, not all of even the most unpromising cases are fatal.

Local function in the cases that do recover is surprisingly good. There may be only moderate loss of rotatory motion and flexion, nothing else.

Coste's case of survival for months with complete unreduced forward luxation; Flecken's case of fortunate reduction of a unilateral axis luxation (forward), reduced after one week; a case of Ehrlich's of one-sided backward luxation; a case of the same lesion reported by Walton, unreduced; Horn's case;† Phillip's case of forward luxation with broken arch complicating it, without cord damage, who lived to die from phthisis, and the author's cases—speak for the possibilities in luxation with or without fracture.

Fig. 27.—Case I, showing the projection of the axis behind.

No doubt many cases of odontoid fracture and fractures of arch and body have recovered spontaneously.

Interesting in this connection is a specimen in the Warren Museum in Boston, of unknown history (No. 970 of the old catalogue), in which there is a sharp lateral tilting of the atlas with a fracture of the articular surface of the atlas; there is no narrowing of the medullary space, and the injury was evidently an old one.

Case I.—C. F. Fell down-stairs, striking back of head. No symptoms at first save soreness. Later, a prominence was found just below

* In a case seen by me in January, 1909, by courtesy of Dr. J. B. Blake (fracture of second cervical vertebra with forward displacement of atlas), there was *repeated* paraplegia, occurring with slight changes of position, disappearing within minutes or hours after fresh hyperextension, for ten days. The patient eventually made a perfectly good recovery, save for partial paralysis of one deltoid muscle.

† Horn (Blasius, from Horn, in Kleinert's Repertor. der Med. Chir. Journalist, Jahrgang 1840, viii, 139) records the following case: He *guessed* in the case of a man who had fallen out of a tree, and who had motor and sensory paralysis of arms as well as legs, and could not raise his head, which had fallen forward, that there might likely be pressure from the odontoid. Accordingly, the atlas was reduced backward, or manipulation to this end carried out. There was a double click, and ten minutes later the paralysis disappeared, and in two weeks the patient recovered.

occiput on left. Pain in area of right lesser occipital nerve, which was persistent.

Was kept in bed with sand-bags as a support until the fourth week. Then put up in plaster (see Fig. 20). This was removed after eight weeks. Motion of neck was regained gradually.

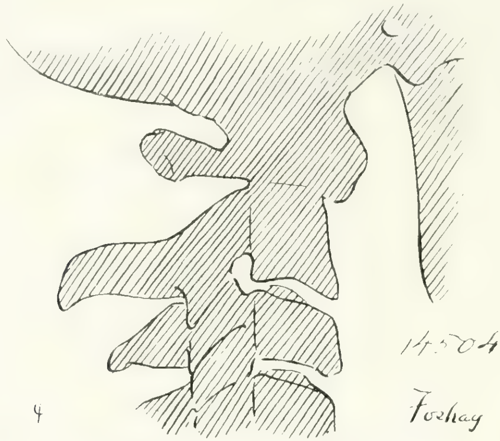


Fig. 28.—Case I: *x*-ray. Shows only the forward displacement of the atlas. Sketch from *x*-ray plate.

January 17, 1908, fourteen weeks after injury, he went back to his work as a compositor. (See Figs. 27 and 28.)

Case II.—T. D., aged forty-eight, entered May 7, 1906. Fell down-stairs. Unconscious for a time, and then showed paralysis of right arm, pain in right side of head, and tenderness of the upper part of the neck, with great pain on any motion.

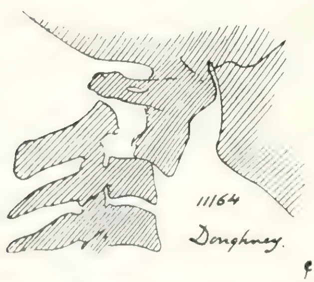


Fig. 29.—Sketch of *x*-ray in case II.

Seen by the neurologist who made a diagnosis (as to the arm) of nerve-root lesion. There was total paralysis, but *no* sensory disturbance.

After three weeks he could move his head without pain and the arm paralysis was nearly gone.

The *x*-ray showed fracture of the axis with much displacement, as seen in Fig. 29.

At four weeks he was up in a Thomas collar. Showed a very slight spastic condition of the right leg. This presently cleared up.

At seven weeks the collar was omitted.

Three days later he insisted on going home. There was nothing abnormal about him apparently, save slight stiffness of the neck, with *no* pain.

Case III.—J. C. Fell from a horizontal bar, striking his forehead. Immediate lameness of neck. A few days later came to the City

Fig. 30. Case III: x-ray and explanatory sketch. The crosses show the displacement of the body of the axis forward, and the break in the arch.

Hospital Out-patient Department, where I saw him at the request of Dr. L. T. Wilson. He was treated as a probable fracture high up. The x-ray showed an axis fracture with displacement. Clinically, he

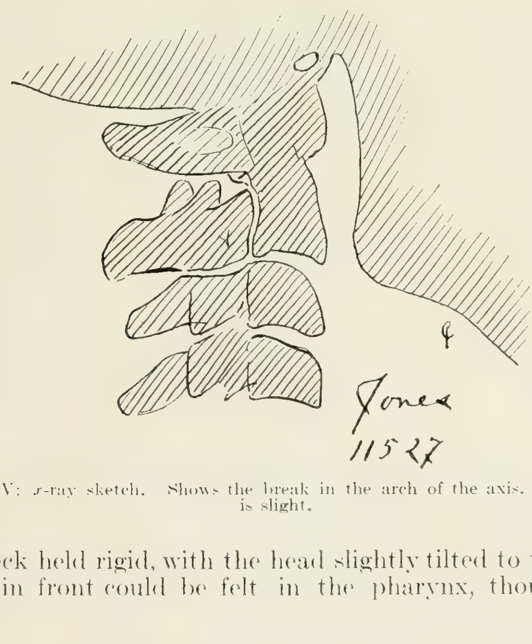


Fig. 31.—Case IV: x-ray sketch. Shows the break in the arch of the axis. The displacement is slight.

showed a neck held rigid, with the head slightly tilted to the left. The prominence in front could be felt in the pharynx, though not very

clearly. He had pain in the neck and in the region supplied by the occipitalis minor nerve on the right.

From the first he walked about in a well-fitted Thomas collar.

December 9, 1908, he showed some stiffness, but had no pain. (See Fig. 30.)

Case IV.—P. J., aged thirty-five. May 23, 1906: Fell over banisters, striking head and shoulders. Unconscious for two hours. Neck rigid, inclined to right. Tenderness of upper neck, and great pain in this region. No paralyses. No bony deformity detected. x-ray shows fracture of axis. (See Fig. 31.)

June 7: Insists on getting up. Head in supporting splint.

June 29: No symptoms. Insists on having all apparatus taken off. Went home against advice, apparently well.

Lesions below the Second Cervical Vertebra

Below the axis we have five cervical vertebræ of substantially similar structure, subject to like lesions.

Below the axis the physiologic movements of importance are rotation and flexion. The traumas affecting this region act, first, by exaggerated rotation; second, by exaggeration of the slight range of normal flexion. Exaggerated rotation gives unilateral luxations, incomplete or complete, or "double rotatory" luxations. Exaggerated flexion leads to double forward luxation or to fracture. Extreme extension acts rarely: it may give backward luxation of one or both sides, or it may produce fracture. In general, backward displacement without rotation (*i. e.*, from blows on the forehead or on the back of the neck) is more apt to occur between skull and atlas or atlas and axis. Lesions of the lower five vertebræ, in fact, almost always show *forward* displacement.

Dislocations and fractures seem to occur indifferently often; both are more common in the region from the fifth to the seventh vertebra—the region of maximum physiologic mobility. Fractures are associated more often with fatal cord damage; distortion of attitude and damage, not to the cord, but to the nerve-roots, rather suggests simple luxation. Dislocation may often occur as the result of a force probably too slight to give fracture.

DISLOCATIONS

The absence of ribs in the cervical region, the mobility of vertebræ at this level, and the nearly horizontal articular surfaces, make possible the occurrence of pure luxations, such as can rarely occur lower down.

Of the dislocations pure and simple we have six types, substantially the same in detail at all heights from the atlo-axoid joint downward.*

* The earliest exhaustive study of these luxations, considered clinically, is to be found in an article in Langenbeck's Archiv, xxx, 1885, p. 192, by W. Wagner, of Königshütte, who has contributed so much to our knowledge of vertebral lesions. The article is illustrated by admirable plates.

1. Unilateral forward, incomplete.
2. Unilateral forward, complete.
3. "Double rotatory," complete.
4. Bilateral forward, complete.
5. Unilateral backward.
6. Bilateral backward.

The incomplete bilateral form has not been demonstrated so far as forward luxation goes. Backward luxation shows no definite distinction between complete and incomplete forms.

All these luxations are most often rotatory in type.

Type I. Unilateral incomplete forward, represents merely an exag-

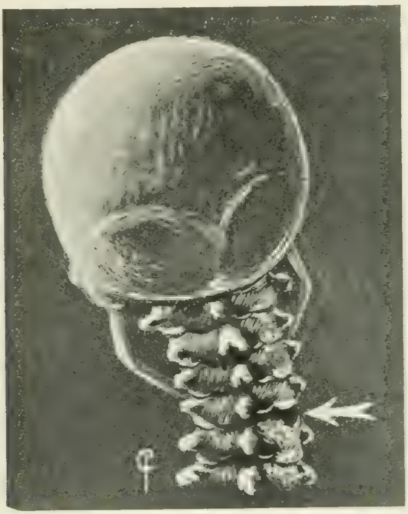


Fig. 32.—Unilateral forward luxation; incomplete (schematic).

geration of the normal mobility; when the natural mobility is overforced, we have "jamming," presumably with a pinching of capsular structures and with some tearing of ligaments.

Where there is an incomplete luxation, the *position* is then not strictly abnormal. It is merely an abnormal *persistence* of the position of extreme rotation.

The position assumed by the vertebræ is as shown in Figs. 32 and 35. The position of the head is shown in Figs. 34, 36, and 37.*

If the luxation is on the right, we have a tilting of the head to the left, a rotation of the chin to the left, and a slight lifting of the chin to the left.

*The obliquity of this motion is a necessary result of the oblique articulations. *Cf.* Fig. 33.

In fresh cases there may be a good deal of spasm, and the neck may be held rigid. There is, as a rule, no considerable pain referable to the bony displacement.

The *tenderness* is sometimes localized enough to be of definite aid in diagnosis.

Even in fresh cases flexion and extension of the head are possible (in the joint between atlas and condyles) to some extent.

When there is less spasm, there may be tolerable mobility, but

Fig. 34.—Incomplete unilateral forward luxation on the left side. Sketch of author's case.

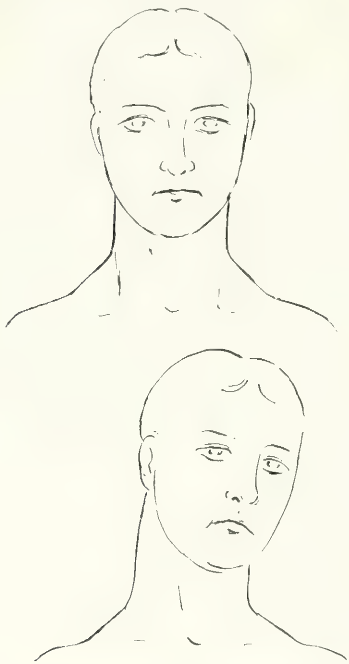


Fig. 33. Shows the normal direction of rotatory motion—not a pure rotation, but rotation with a tilting in abduction.

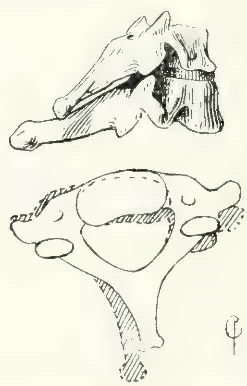


Fig. 35. Unilateral (right) incomplete rotatory luxation.

whatever the mobility of the head, there is a definite "bony" resistance to rotation toward the damaged side, short of the normal limit, and the lateral tilting remains obvious in all positions.

An important sign in diagnosis is that we have in these cases little or no tightening of the muscles, especially no sternocleidomastoid spasm. This sharply differentiates the condition from a traumatic sternocleido lesion with torticollis, which gives a like tilting, though with an opposite rotation of the chin, and shows obvious spasm of this muscle.

Type 2. Unilateral Complete.—In this form we have a position *essentially abnormal.* In this form the upper vertebra has been so far

Fig. 36. Sketch of case of unilateral forward luxation on the right. Reduction was easy, recovery perfect

Fig. 37.—Unilateral (right) incomplete luxation. Even on rotation the tilting of the head persists.

rotated that the projecting posterior edge of the articular process has slipped into the intervertebral notch. So soon as this slipping takes place there is an instant change.

The *lateral inclination* of the head is *reversed*, without reversal of the rotation, and the position becomes that of Fig. 41. The head shows, in a right-sided lesion, slight lateral inclination to the *right*, with rotation of the chin to the left.

Here again we miss the spasm of the sternomastoid which is almost inevitably present if other causes than luxation determine a like position of the head. The *attitude* of torticollis and that of the complete unilateral luxation are the same.

There is loss of motion, of course, and almost inevitably symptoms of nerve-root pressure on the side of the injury.

This takes the form of radiating pain down the arm.

Inasmuch as these luxations usually occur low down in the neck, it is the roots of the *brachial plexus* that are affected,* and as it is a *root* lesion we get pain, involving not the distribution of single nerves, but *zones* corresponding to the *roots*, as sketched in Fig. 54.† In a few cases there may be not only pain, but motor or sensory loss in some part of the arm. The pain in these cases varies with, and in some measure is dependent on, motion of the neck.

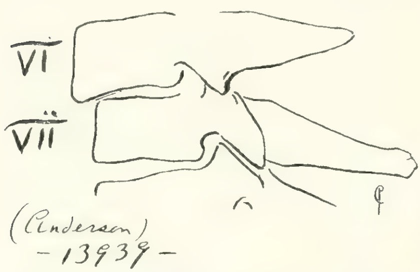


Fig. 38.—Sketch from x-ray of a case of unilateral (incomplete) rotatory luxation (courtesy of Dr. Paul Thorndike).

Fig. 39.—Area of pain and partial anesthesia (promptly relieved by reduction) in Dr. Thorndike's case (see Fig. 38).

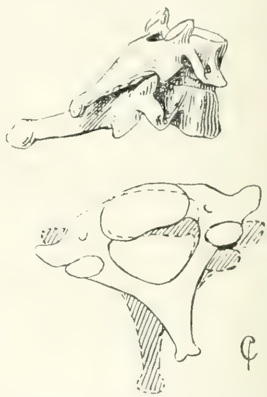


Fig. 40.—Right unilateral rotatory luxation forward: complete.

Type 3. Double Rotatory Luxation.—The double rotatory cases are a combination of forward luxation on one side, with a slight backward displacement on the other. In one autopsy of a case of my own the luxation (between fifth and sixth cervical) showed the fifth vertebra

* Nerve lesion from pressure in the notch must be carefully distinguished from damage of the plexus in the neck from stretching. It is limited to nerves of *one* segment; stretching may damage the whole plexus.

† For much of the information used in preparing all the drawings of zones and areas of sensory disturbance the writer acknowledges indebtedness to the admirable studies of Head and Sherren, Brain, vol. xxviii, p. 116, November, 1905.

luxated back in such fashion that the articular surface of the sixth rested in the lower intervertebral notch of the fifth.

Fig. 41.—Right unilateral luxation: complete.

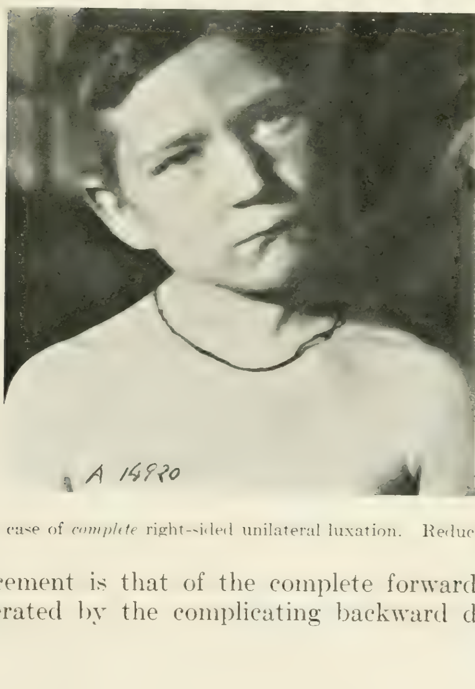


Fig. 42.—A case of *complete* right-sided unilateral luxation. Reduction refused.

The displacement is that of the complete forward luxation, only slightly exaggerated by the complicating backward displacement on the other side.

6

Type 4. Bilateral Forward.—In the fourth class, the bilateral forward luxation, we are dealing with the result, not of rotation, but of forward shove and of flexion—the same force that so often makes for fracture.

The position of the vertebral bodies is as shown in Fig. 43. The attitude is

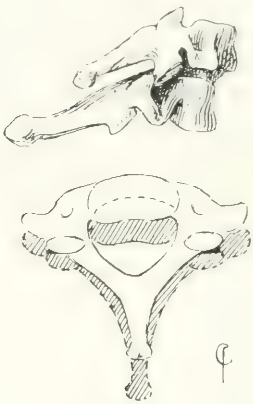


Fig. 43.—Bilateral forward luxation.

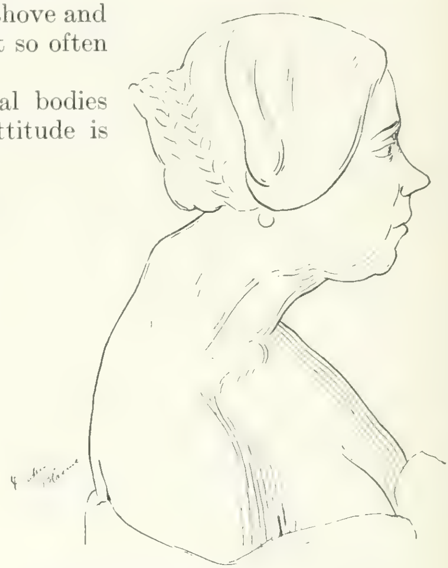


Fig. 44.—Forward luxation (after Blasius).

Fig. 45.—Forward luxation (after Blasius). Question of fracture also.

shown in Figs. 44 and 45, sketched after the plates of Blasius. This form is relatively rare; the writer has seen two cases

only.* Blasius, in his wonderfully complete monograph, gives 54 bilateral luxations, against 37 unilateral, but it must be noted that this paper is based mainly on a study of reported *autopsies;* bilateral luxation is apt to be fatal; unilateral luxations rarely, if ever, cause death. So far as *surviving* cases are concerned, it seems that the great majority are unilateral. Certainly this is true not only of my few cases, but of those of which I have knowledge in the practice of others.

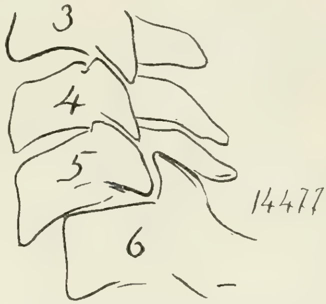


Fig. 46.—Bilateral forward luxation (with cord symptom) (courtesy of Dr. F. B. Lund).

Type 5. Unilateral Backward.—Blasius gives but one good case—that of Ollivier, a luxation of the sixth—and one doubtful case. Ollivier's case showed no obvious deformity, but it was complicated with extensive fracture of the seventh vertebra, so it tells us nothing to the purpose.

Necessarily, there would be in such an injury a persistent *rota-*

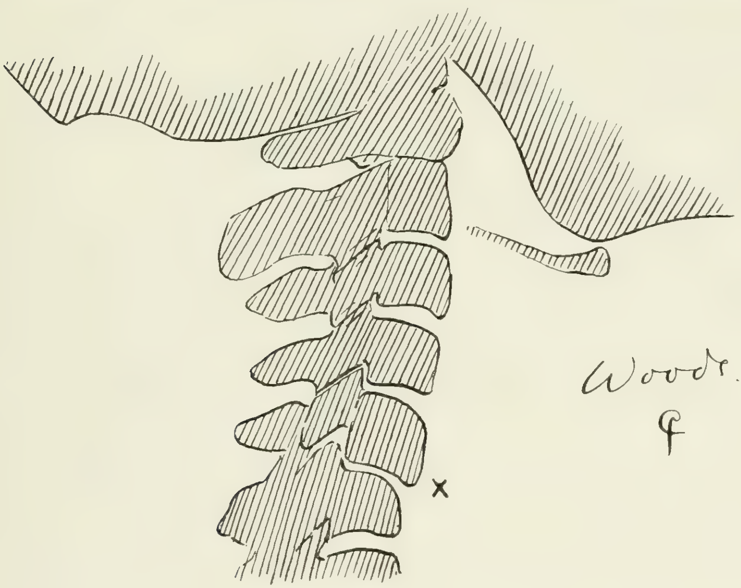


Fig. 47.—Forward luxation of fifth on sixth; temporary signs of cord pressure.

*There are several cases on record, however, of bilateral forward luxation where the attitude differed greatly, there being only a shortening of the neck, apparently, and an exaggeration of the normal concavity at the nape, and in some cases there has been actual *backward extension* of the head. In regard to rigidity and pain there is great variation. The neck may be pretty freely movable.

tion backward on the injured side; beyond this we can say nothing definite.

Type 6. Bilateral Backward Luxation.—The classic symptoms are backward and upward extension of the head, hollowing in of the back of the neck with deep skin-folds,* prominence of the larynx and trachea, with difficulty in swallowing and talking, or even in breathing.

Fig. 48.—Dislocation forward of sixth cervical vertebra from fall on head. Total paralysis below nipples. Temperature rose to 110° F. Died eighteen hours after accident. Illustrates displacement of spinous processes (Warren Museum, specimen 4904).

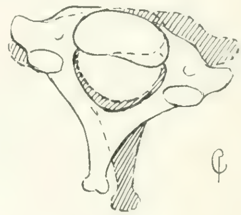


Fig. 49.—Unilateral dislocation backward.

The transverse processes below the luxation are prominent.

Fig. 50.—Classic attitude for double backward luxation.

* There are exceptions, and cases amply attested by autopsy have shown a flexion of the head well *forward*, with *backward luxation*, but they are a few, not the rule.

The head is held immovable.

The neck looks shortened.

Fig. 50, based on the plates of Ayres' case, shows the attitude.

Diastasis—tearing of ligaments without formal luxation and without fracture, save for chips torn loose by the ligaments—is common in this region and figures in a number of autopsy reports.

These cases commonly show stiffness and localized tenderness, without abnormal attitude, and with a negative finding on *x*-ray examination. They are apt to be associated with traction damage to the plexus or to nerve-roots of at least one side.

Fracture Luxations with Displacement

These involve various details of lesion, but this injury in the cervical region is usually fracture by flexion, with slipping of the upper vertebral

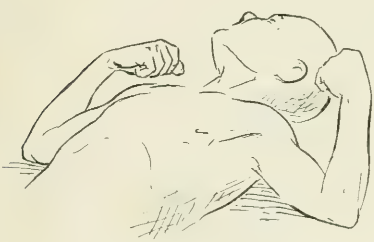


Fig. 51.—Injury to segments V and VI (after Thorburn).

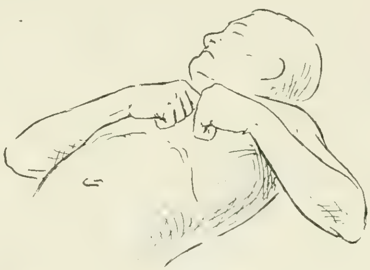


Fig. 52.—Injury to segments VI–VII (after Thorburn).

fragment forward on the lower. The diagnosis of these cases is based, as a rule, on the diagnosis of the cord lesion or on the *x*-ray picture. The *local* signs are confirmatory, rather than diagnostic. Any considerable displacement here involves pressure on the cord, and the diagnosis as to the presence and height of the cord lesion, and, therefore, of the height of the fracture, is apt to be far more accurate than can be made from an examination based on objective signs in the neck.

Fig. 53.—Sketch of a case of the writer's: total lesion at the sixth segment.

Cord lesion may occur without fracture, but fracture with displacement rarely occurs without damage to the cord that can be sharply localized. *Luxation* without cord lesion is common.

Of the fracture cases that come up for diagnosis, we have usually only those below the fourth spinal segment, for fractures with cord damage above this point almost invariably involve the cord origins of the

phrenic nerve, and are fatal long before the question of diagnosis comes up.

Below the fourth segment we have, so far as the clinical signs of cord damage go, three types, almost instantly differentiated on sight according to the *motor* damage.

If the damage is *above the fifth segment*, the arms are entirely paralyzed.

If the damage is a little lower, involving the *fifth and sixth* segment, we get the picture of Fig. 51. This means damage involving the cord up *to* the fifth segment.

If the damage is only *to the sixth*, we get paralysis of the hands, not of the arms, and a position like Fig. 52 and Fig. 53.

Differential Diagnosis of Injuries below the Axis

If we have a case of injury to the neck, our consideration of diagnosis starts, not from known *pathologic* data, but from ascertainable *symptoms* to be used for diagnosis—a very different matter. In examining such a case the first thing to be settled is whether or not the patient has paralysis. If he has, we must first make up our minds as to the probable *height* of the lesion.

If the paralysis is *total*, we know it must be from an injury below the fourth segment. Injuries higher up with *total* damage are instantly fatal.

Partial paralysis may come from injury at *any* level or from nerve-root lesions alone.

Total paralysis of the type of Fig. 51 means *fifth* segment. Total paralysis except for upper arm action in flexion and rotation (see Fig. 52) means *sixth* segment.

Partial paralysis *below* the level of the arms necessarily means *cord* injury.

Partial or total paralysis of one or both arms means *either* lesion of the cord *or* injury to the brachial plexus or nerve-roots.

Sensory disturbances are of value, as a rule, only in defining the level of hopeless transverse lesions of the cord, or in *defining* injuries of the brachial plexus or of the nerve-roots.

The levels of the sensory distribution corresponding to the various segments of the cord are indicated in Fig. 54.

Disturbance of the sympathetic nerve is shown particularly by unilateral contraction of the eyelid opening ("verkleinerte Lid-spalte"), and at times by *unilateral* sweating. It depends on damage to the anastomosis between sympathetic and cord at the level of the first dorsal segment.

Priapism (simply a soft engorgement of the flaccid penis, as a rule) is pretty constant in the total lesions; it may help out in the diagnosis in unconscious or drunken subjects.

A like condition occasionally occurs where there is only very slight cord compression.

Deformity.—If the displacement is *forward*, it may be—1. Double forward luxation. (See Figs. 43 to 46.) 2. Fracture with forward displacement. 3. Distraction.

There is no accurate differentiation of the first two. On the whole, there is a possibility of greater displacement without serious cord damage in luxation than in fracture. Displacement of spinous processes and

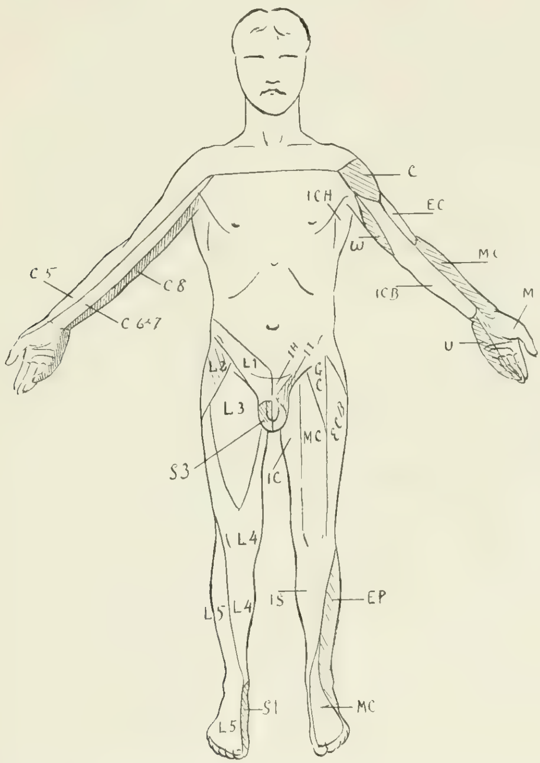


Fig. 54.—Shows areas supplied by individual nerves on the left side—"root-zones" on the right.

transverse processes is common to both, and of similar grade. Crepitus is not justifiably obtainable unless by accident.

"Distraction" must be differentiated on negative evidence. There may be deformity (in the upper vertebræ it is asserted that there usually is), but this is in the form of forward flexion only;—the relation of the landmarks one to another is not notably disturbed. There may be no such deformity at all—only rigidity and tenderness.

Obvious *backward* displacement of the head means—(*a*) Double backward dislocation of *any* vertebra. (*b*) Double *forward* dislocation.

Both these are rare. If the displacement be above the fourth verte-

bra, an examining finger in the pharynx will usually differentiate. Otherwise palpation of the spinous and of the transverse processes is our only help. In such case the skiagraph may give welcome evidence.

Fracture with *backward* displacement seems to be even rarer than luxation. Here again we should have to depend on the x-ray for accurate differentiation.

If the displacement is *lateral and backward*, we may have either luxation or fracture luxation.

If the displacement is *forward with rotation*, more especially if there be no symptoms of cord pressure (whether with or without signs of root pressure), the probability is that we have to deal with a pure luxation.

If the head is inclined *away* from the side that shows local tenderness and palpable disarrangement of transverse processes, and possibly nerve-root signs, then we probably have incomplete rotatory dislocation forward—*the commonest type of pure luxation.*

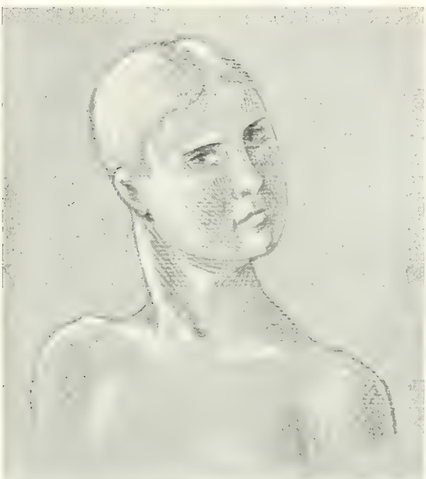


Fig. 55.—Attitude in right-sided torticollis.

If the lateral flexion is reversed,—*toward* the injured side, with rotation still *away from* the damaged side,—then the luxation is a complete rotatory forward.

It is possible in these cases of *rotatory* luxations to make the diagnosis with some degree of certainty without the x-ray.

That the x-ray may be of service is obvious from Fig. 38.

It will be obvious from the foregoing that the differentiation is at best only approximate in many cases; there are not only these type lesions, but a whole series of *atypical* fractures and fracture luxations that often show no appreciable displacement, to say nothing of the self-reduced luxations and of the "distractions" in which there is practically no displacement.

Rigidity without deformity *per se* does not *prove* anything.* There may be distraction, self-reduced luxation, fracture with little or no displacement, or even muscle soreness alone.

Signs of nerve-root lesion, or more especially of cord lesion, in com-

* *Absolute rigidity*, like that of meningitis, I have seen in one neck fracture and in three fractures of the skull base. Presumably, the irritation of meningeal hemorrhage may rarely give this as a reflex result, just as meningeal suppuration commonly gives it.

bination with a rigid neck without deformity, point to "distraction." Fractures are not likely to produce such lesions without demonstrable displacement, and distractions are commoner than self-reduced luxations.*

A condition to be considered is torticollis—directly traumatic from muscle strain or of the "rheumatic" sort. As a rule, torticollis involves the sternomastoid muscle. The differentiation is by attitude (see Fig. 54), and more particularly through the fact that the sternomastoid or the posterior neck muscles are tense in torticollis *on the injured side.* In the rotatory luxations and with all *displacements the tension is slight and almost invariably on the other side.*

It is even possible to have serious *cord* damage without vertebral damage. This may be from hemorrhage outside or within the cord. The mechanism of production usually seems to be one of overflexion, with tension in the length of the cord. Serious compression of the cord is not common without displacement of vertebræ, however.

Clinical Conclusions

To sum up: about all that can be claimed is that it is usually easy to be sure that we have to deal with an injury to the spine in this region. Beyond this the surgeon who has a reasonable experience with this class of cases can, as a rule, distinguish without much question three important classes:

(*a*) The *rotatory* luxations, readily and completely relievable.

(*b*) The cases without displacement, with or without lesion of cord or serious damage to nerves, with or without definite fracture or "distraction" lesions—cases to be let alone except for support.

(*c*) The fracture dislocations, with apparently irreparable cord lesion,† in which treatment is useless if the diagnosis be correct, but cases in which any immediate treatment may be justified on the chance of a lucky error in diagnosis.

Beyond this range diagnosis in detail is uncertain, and, though helped by a good x-ray, is often left uncertain.

Treatment of Luxations

Rotatory Luxation Forward—Unilateral—Incomplete.—These cases not uncommonly cure themselves. I have seen three undoubted cases, all in children, which reduced themselves while the children lay in bed—

* It must be borne in mind, however, that falls on the side of the head and on the shoulder not very uncommonly involve damage to roots or plexus without *any* injury to the vertebral column at all, so that nerve lesion is indicative of damage to the *spine* only in the presence of some *direct* sign of such damage.

† There is no *absolute* distinction of these cases, even *total* paralysis with total abolition of reflexes (patellar, Achilles, plantar, etc.) does not *prove* a total transverse lesion. The question of these lesions is considered in the following among many articles: Thomas: Boston City Hospital Med. and Surg. Reports for 1900; Walton: Jour. Nerv. and Mental Dis., January, 1902.

not very quietly awaiting parental permission to operate. Cases are

Fig. 56. Grip for reduction of neck luxation.

Fig. 57. Another grip for reduction.

recorded where reduction occurred under ether, prior to any attempt at reduction.

Reduction is ordinarily easy. Ether is advisable—not actually necessary.

The patient lies on his back, with the head and neck projecting over

Fig. 58.—A third grip for reduction. This is the strongest and usually the best grip of those shown.

the head of the table. The operator takes one of the grips shown in Figs. 56, 57, and 58, and with very slight traction swings the head *away from* the side of injury, first rotating this side forward to disengage any obstruction, then gradually rotating *backward* while the lateral abduction is maintained. (See Fig. 59.) In this way the articulation of the sound side is used as a fulcrum and a fixed point about which the reduction is made. Little force is needed. The bones slide into place (sometimes without any click), and normal position and motion are instantly restored. I have in this way reduced five cases.

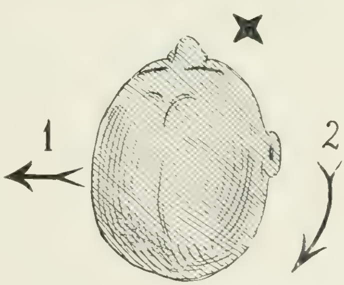


Fig. 59.—For the right-sided luxations the head is abducted to the left (1) and rotated down and back on the right (2).

In the **complete forward luxation** the reduction is the same, save that we abduct toward the *uninjured* side somewhat more vigorously, to make sure that the articular process clears the notch into which it has slipped.

In the cases of *bilateral luxation forward* the reduction is the same, but one side is reduced at a time.

The *double rotatory luxation* (one side forward, the other back) is probably indistinguishable clinically. If distinguished, it could not be treated otherwise than by simple reduction as for unilateral forward luxation.

As to the *backward dislocation*, single or double, there are practically no data. The reasonable procedure obviously would be traction up and away from the side injured, then flexion and rotation *forward* on the injured side, provided the lesion was unilateral.

In *bilateral luxation backward* the manœuver to be carried out is traction up and slightly backward (*i. e.*, extension of the neck) to disengage the entangled processes, then *flexion* to reduce them, carrying the vertebra forward to its proper place.*

Treatment of Fractures and Fracture Luxations

Fractures in this region that are *not* associated with cord injury do not ordinarily call for any reduction manœuvers. The exception is in case of considerable deformity, as in the case shown in Fig. 60; in such a case it may be well to reduce, remembering that in these fractures, unlike the luxations, we do not know the precise kind or amount of damage, or whether there is in the given case a risk of *overreduction*.

Cases of damage to nerve-roots by pressure at the foramina are usually bettered by hyperextension—simply by *keeping* the neck hyperextended, not by reduction procedure.

All these cases should be kept in bed with the head steadied by sand-bags for two to four weeks, then put up in a plaster helmet or Thomas collar. Support should be continued for at least a month longer to be on the safe side, and some caution in avoiding falls or jarring is indicated for some time thereafter.

As to treatment of *fractures* or of *fracture luxations with cord damage* there is little to be said that is not open to dispute.

In this region pressure on the cord that suffices to give paraplegia means usually a transverse *total* lesion of the cord, which is beyond the present resources of surgery.

Such a lesion means permanent paralysis, with death resulting at an interval varying from twelve hours to many months.

Here and there laminectomy, or forcible correction without incision, has seemed to be the determining cause of recovery, total or partial. In competent hands either operation is next to harmless, and is always justifiable, if not hopeful.†

We cannot remedy total transverse lesions occurring *at the time of the*

* Hamilton: Fractures and Dislocations, third edition, p. 523, cites Ayres, who successfully reduced such a case by a manipulation similar to that described.

† A series of cases of forcible reduction recently collected by Steinmann (Arch. f. klin. Chir., 1906), of 20 cases with 12 successful reductions without laminectomy, gives by far the most hopeful view of any recent paper.

trauma, but may relieve any trouble due to persistent pressure. Such persistent pressure may be due to displacement of one vertebra on another, or to smashing in of the laminæ into the canal, or to hemorrhage between meninges and bone, or within the meninges, or inside the cord.*

If we feel that there is *even a small chance* that paraplegia is due to such pressure, not to damage already done, it is our duty to act and to operate immediately, even if the detail diagnosis cannot be made before operation.

After reduction, whether by forcible correction or by laminectomy, the problem is one of fixation. The tendency to *recurrence* of displace-

Fig. 60.—Fracture dislocation of the fourth cervical vertebra. Taken four months after accident (Peckham and Hammond).

ment in pure luxation is very slight.† In fractures, reduced or operated, it is greater. In fractures, originally without displacement, and in distraction injuries in the lower neck, the tendency to displacement is slight, and patients often refuse or remove apparatus without damage.

Our means of fixation are, here, as in the higher injuries, sand-bags while the patient is in bed; after he is ready to be up, a plaster helmet

* If we could be sure of the hemorrhage cases, they might be let alone, as clot pressure diminishes pretty promptly. In two recent cases of the sort in which the neurologist, Dr. J. J. Thomas, and I felt that the trouble was due to clot pressure, no operation was done. Both cases showed paralysis, nearly complete, both of arms and legs. One recovered entirely; the other recovered entirely except for ulnar atrophy and a slight spastic condition of the legs.

† There is one case of reported recurrence after reduction—that of Wittfeld.

or a Thomas collar, or its pasteboard modification, may be used, according to the gravity of the case. Support is to be long continued.*

Prognosis

Dislocations *without marked cord lesion* when reduced do well. Associated *motor nerve injury* usually recovers either at once or later, within the two to six months needed for nerve regeneration. Sensory disturbance usually disappears promptly, though pain may persist longer. Any serious neck stiffness lasting beyond a few weeks is not to be expected.

Fractures *without cord injury* do well, but repair is slow, and, in proportion to unreduced displacement, there is apt to be rigidity of the neck or an eccentric holding of the head.

Fractures or luxations *with severe cord injury* in this region usually do badly, with or without surgical aid, even if the lesion is not complete. Many cases succumb promptly to ascending myelitis ("red softening"), showing prompt hyperpyrexia, semicoma, and respiratory disturbance,† accentuated by abdominal distention and the resulting dyspnea.

Other cases survive only to succumb to sepsis from ascending vesical and pyelonephritic infection, or to sepsis and exhaustion from the "trophic" bed-sores which are hardly to be avoided in these cases, even with the best care.

Here and there improvement or actual recovery follows, with or without operation, as the case may be.

Such improvement seems to occur most often in cases where there is compression not by bone, but by clot (see cases above noted).

* In a case reported by Drs. Burrell and Crandon (Jour. Amer. Surg. Assoc., 1905, xxiii, p. 80) the patient at first showed no cord symptoms. At four days he sat up against orders, and *immediately* complained of numbness of legs and body. Examination showed paresis from the neck down, with diminished sensation. Two days later paraplegia was complete from the muscles supplied by the sixth and seventh segment downward. Operation was refused. Death occurred after a month. Autopsy showed a fracture of the first dorsal vertebra.

† Most marked at about the second day—as dyspnœa alone or with actual lung edema, not rarely giving pneumonia as the secondary result. The following cases of the writer's are significant:

C. V., August 15, 1907, was struck on the back of the neck by a beam. Showed a "knuckle" at the seventh cervical spine. Total paraplegia with loss of sensation below the fourth rib; knee-jerks absent. Apparently a lesion of the seventh segment. Showed loss of sensation of the extensor surface of both arms. At entrance he showed some disturbance (rapidity) of respiration. The paralysis extended, with eventual loss of all motor power at a level corresponding to the sixth segment.

At two days he developed a right-sided pneumonia and died within a few hours.

W. T., aged thirty-four. Seen by the writer August 10, 1907, forty-eight hours after falling down-stairs. Respiration rapid and shallow. Heart-apex outside the nipple. Abdomen distended. Hand grasp weak on both sides. Paresthesiæ of both arms on the ulnar side. Anesthetic from the nipples down. Paraplegic. Tenderness at the seventh cervical. No deformity. Reflexes gone. Respiration got better; involvement of arms improved.

In course of transfer to the ward was carelessly handled, apparently, promptly became cyanotic, and died of respiratory failure.

CHAPTER V

DORSAL SPINE

Landmarks.—We have to consider here only the spines and arches. The bodies and transverse processes are beyond reach.

The line of the dorsal spines, seen from the rear, is substantially straight; there are here no bifid spines to confuse us, and any normal lateral deviations are usually so slight as not to count.* On flexion the spines stand out better and their line may be made out even in fat patients.

There is some variation in the length and prominence of the spines, but, as a rule, they are pretty even, with two exceptions—the first and the twelfth dorsal. The first is prominent: very often it is this first dorsal and not the last cervical that is the "*vertebra prominens.*" The second spine is less prominent, but the change in level beneath the first is not conspicuous.

The last dorsal spine in most individuals projects no more than the rest, but not uncommonly it is of greater actual length, or the contrast between it and a much shorter first lumbar spine gives it a prominence which at times is very conspicuous and looks abnormal.

The arches of the dorsal vertebræ are not ordinarily palpable under the great muscle masses. They may, however, be felt vaguely as a firm resistance under the muscle. The distance from the arches out to the skin is, in fact, far greater than would be estimated, even in non-muscular subjects.

INJURIES OF THE DORSAL SPINE

Here we are confronted with the same classes as in neck injuries; dislocations, fracture dislocations, fractures without much or any displacement of the bodies, and "distraction" lesions. The determining trauma may be a direct blow, but is usually a forced flexion. Hence it is that the lesion is commonly very low down (tenth to twelfth dorsal), where the spine is least resistant to flexion strain.

Causes.—In some cases dorsal injury results from a fall on the back—from *direct* violence. Indirect violence acts rarely in case of falls in the sitting posture, the impetus of the falling head and trunk producing a sudden forced flexion. Forced flexion acts in another way more com-

* The "normal" lateral curvature described in the anatomies I have rarely been able to find clinically.

monly, namely, in cases where a driver is caught by a low door, or where in other fashion a very forcible though slow compression in flexion is exerted. Something in the back must give way—it may be that there will be a simple tearing of ligaments, a "distraction," or there may be fracture, the vertebral body giving way obliquely down and forward. Such fracture is usually at or near the dorsolumbar junction, the point of greatest mobility and least strength.

Fig. 61.—Mechanism of flexion fracture as it occurs when a driver is caught between his seat and the top of a doorway.

Displacement of the upper fragment *backward* is rare—it seems to be due always to a fall in which the lower portion is checked against some firm object, while the momentum of the upper part of the body backward causes both fracture and displacement. Theoretically, pure hyperextension may also give this displacement.

Dislocation

Dislocation absolutely without fracture *may* occur and is attested by various autopsies.*

Dislocations without fracture are, however, incomparably less common than in the neck, owing, in the main, to the supporting relation of the ribs to the spine; they are, in fact, so rare as to become clinically insignificant.†

Of Blasius' list of dorsal luxations there are 22 in all. In five the displacement was forward, backward in five, double rotating in one, that is, forward on one side, back on the other.‡ One case was a unilateral backward displacement, two are recorded as directly to one side.

This list, however, includes many cases with associated *fractures*, more or less extensive.§

Of these luxations 11, exactly one-half, were at the point most often

* And also cord injuries from overflexion involving *no* bone lesion.

† Hamilton (*loc. cit.*, p. 515) quotes one case.

‡ Such a double rotatory case in my own series is here given (but there was also a laminar fracture): M. F., aged thirty-three, August 16, 1906. A staging fell on him. There was a knuckle at the twelfth dorsal and a separation of the spinous process of the first lumbar. Total paraplegia; sensation gone below the pubes. Transferred from the Relief Station to my care. Laminectomy August 18, 1906, showed the twelfth dorsal vertebra twisted forward on the right, with subluxation backward of the articular process on the left. Save for a fracture of the lamina of the twelfth dorsal there was no break evident. There was no continuing pressure, and the dura was untorn, but on opening the dura a complete or nearly complete crush of the cord was found. The operation did no good and no harm. He was discharged unimproved October 5th.

§ Four seem free from doubt as to fracture. All these cases are of *backward* luxation.

damaged by fracture, namely, at the lower end of the dorsal spine. Granting the possibility of luxations of the dorsal vertebræ as proved by

Fig. 62.—Specimen in Warren Museum (4629). Fracture of twelfth dorsal from fall. Total paralysis, but lived two years.

postmortem, it is perfectly fair to say that such lesions cannot be diagnosed, that in cause, site, symptoms, complications, prognosis, and in the indications and the possibilities of treatment they cannot be differentiated, and that it is of no importance that they should be differentiated from fractures in this region.

Fig. 63.—Fracture of twelfth dorsal vertebra. Laceration of intervertebral disc above twelfth vertebra. Paralyzed from below navel.

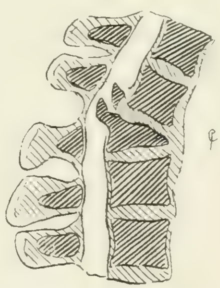


Fig. 64.—Specimen in Anat.-Path. Mus. zu Giessen, No. 35-168*a*. Sagittal section. Sketched after Gurlt's plate. Shows pressure on the cord by the displaced wedge fragments.

Fracture Dislocation.—The lesion is most often a displacement of the upper portion of a vertebra on the lower part of the same. The torn ligaments and displaced joints often present are unessential.* Pressure on the cord is between the displaced arch behind and the fixed portion of the body below the fracture. (See Figs. 62 to 64.)

Flexion of the column, as a whole, at the point of break is a factor in pressure, as is also the shoving backward of a not infrequent wedge-shaped bone-fragment on the cord. (See Fig. 64.) Rarely pressure is from fragments set free by fracture of arch or lamina: such pressure is more apt to occur in cases of fracture by *direct* violence, than in the commoner type of fracture by flexion. Here, as in the neck, signs of severe cord damage may accompany pressure from clot without *any* bone damage at all.

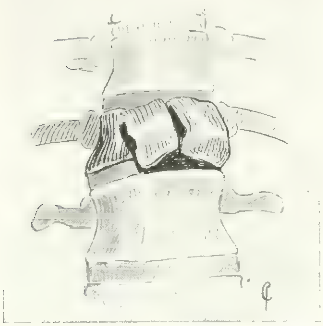


Fig. 65.—Fracture by crushing (*i. e.*, flexion) of the twelfth dorsal vertebra. Sketched after Gurlt's plate.

Fracture or dislocation, with like displacement, without cord pressure, is not common. The canal is here narrow, and little slipping is needful to give pressure.

The cord is usually severely and irremediably damaged at the time of accident. Here, as in the neck, there is no *reliable* sign of total cord lesion. Abolition of reflexes† is highly suggestive of *total* cord lesion, but not conclusive.

The most common site for these injuries, save those from a *direct* blow, is low down, about the tenth dorsal to the twelfth.

Displacement, as a rule, is of the upper portion forward on the lower.

Some degree of lateral deviation is common; a deviation *predominantly* lateral is rare.

Fracture of the Spine without Displacement of the Bodies

Fracture of the body of a vertebra does not occur without some little displacement, though it may escape detection.

Fractures of the lamina may occur without displacement of the bodies. Such fractures give cord pressure usually, and, discovered accidentally at operation, furnish the best cases of recovery after laminectomy. Unfortunately, they cannot be diagnosed. If there is no general deviation of the spine, but a deformity in the line of spinous

* As a curiosity only, we may note a case reported by Jouon (Revue d'Orthopedie, vii, 1906, p. 39) in which there was a separation of the upper *epiphysis* of the dorsal vertebra forward.

† Loss of patellar and tendo Achillis reflexes and of plantar reflex.

processes, and if crepitus is felt, we may *suspect* fracture of an arch or lamina. We cannot be sure of it. The x-ray does not help.

Fracture of a spinous process not very infrequently results from direct violence, or may occur as a *complication* of fracture of body or arch. It may be diagnosed by the abnormal position of the spinous process, which is movable laterally. There may be crepitus. There is pain, and the region is tender. There are no cord or root symptoms. The presence of such fracture does not argue against *associated* fracture of the body.

The treatment of fracture of the spinous process is simply rest—fixation of the fragment is impracticable without operation, which is not called for. The result is union, apt to be fibrous rather than bony. The injury involves no permanent damage, save perhaps some slight loss of strength and flexibility.

Distraction

Distraction.—The only form of "distraction" of *clinical* interest, that is to say, the only form in which a diagnosis may be made, is that in which the interspinous ligament is torn. Here and there such cases turn up. They are characterized by local pain, by a kyphosis seemingly beyond the normal, and by the separation of two adjacent spinous processes that is beyond the normal variation. This separation tends to increase on flexion of the spine, is reducible by hyperextension, and is associated with more or less localized pain and tenderness and ecchymosis. Nerve-root symptoms are usually lacking. There is often no gross displacement.*

In these cases of distraction in the dorsal region the kyphosis is a *reducible* one, localized definitely at one point, and not associated with any irregularity of spines, other than their separation.† There is a decided chance of overlooking a slight *irreducible* kyphosis from body fracture. It is to be remembered that torn ligaments in no way *exclude* fracture.

DIAGNOSIS

As a rule, utter helplessness is the immediate result, *from local pain*, even if not from paralysis. If the patient is unconscious, drunk, or

* C. F. Painter has reported some cases of interest in this connection, some of which involve probably fracture, as well as "distraction." Painter and Osgood: Boston Med. and Surg. Jour., 1902, cxlvi, p. 1.

† O. P., woman of thirty-six. Caught under the fender of a car. Seen by me August 30, 1907, and October 14. Never showed cord symptoms. Showed at the twelfth dorsal vertebra a separation of the spines, with a kyphosis which, with the separation of spines, was reducible by moderate forced extension. She refused any treatment. When seen nearly two months later, she showed no signs of cord damage, unless we may so class slightly increased reflexes at knee and ankle, and complained mainly of inability to sit or stand for a long time. There was no longer any *reducible* kyphosis, but there was a slight permanent kyphos. This case I regard as a pure "distraction."

in severe shock, or if there are other severe injuries associated, the lesion of the spine may not be obvious. In unconscious cases loss of reflexes, or oftener the reflex priapism, may give the necessary suggestion of cord lesion. This priapism is usually only a *soft* engorgement of the penis, but often of considerable size.

If the patient is conscious, there is, as a rule, severe pain in the back, often radiating around the chest or belly.

There is often (important in differentiating actual associated visceral lesions) a rigidity of belly muscles and a tenderness of the belly obviously due to the spinal lesion, but not adequately explained.

Passive motion (or active motion, if that be possible) of legs or pelvis gives pain at the site of the injury, but there is apt to be *rigidity* from spasm, rather than increased mobility.

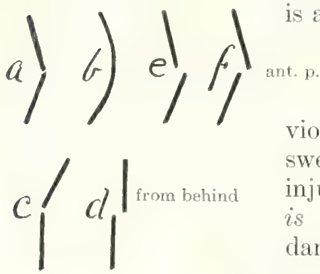


Fig. 66. *a–f* show the profile view; *c* and *d*, the view from behind. We may have in profile an angle (*cf.* Figs. 62–64, and Fig. 69), or what is apparently only a curve, as in *b*. On palpation we usually find definite displacement; this may be of either the upper (*e*), or more rarely the lower, fragment forward (*f*), though in either case the deformity is one of kyphosis. Seen from behind we may have an angle (*c*) or a "jog" (*d*).

Local examination shows, as a rule, a hematoma.* If there has been no *direct* violence there is none the less apt to be some swelling of the soft parts about the seat of injury, and later a marked ecchymosis. *This is significant:* practically it means spinal damage always.

Tenderness locally is usually great.

Deformity.—First we must regard deviations in the *general* line of the spine in *two* planes. Anteroposteriorly, we may have type (*a*) and type (*b*), where no *exact* point of projection can be made out. (See Fig. 66.) Seen from behind, we may have lateral deviation of types (*c*) or (*d*). On *palpating* the region of damage we usually find irregularity in the line of spinous processes, the upper forward, as in (*e*), or back, as in (*f*). It is, however, a change in the line *as a whole*, not failure of two spines next to one another to agree, that often gives diagnosis. (See Figs. 67, 68, and 69.)

Displacement may be considerable, but often in the worst cases it seems slight, for cord damage may occur even in simple overflexion, with or without distraction, or even without any fracture; on the other hand, some displacements, having done their appointed damage, seem to reduce themselves in part—to snap back, so to speak.

In making diagnoses we must bear in mind that the spinal column varies a good deal as to prominence of spines. Very frequently the

* In cases due to glancing blow on the back by a heavy object, there is at times a loosening (what the Germans call a "Schindung," a "shelling off") of *all* structures between skin and ligaments, and a colossal hematoma. This proves nothing as to damage to the spine, though it is suggestive of such damage.

last dorsal spine is normally so prominent as to suggest something pathologic.

If there is *total* paralysis, the *top* of the area of disturbed sensation gives us a guide as to height of the cord lesion. If there are symptoms of nerve-root damage, radiating pain, local anesthesia, paresthesia, or motor disturbance, this gives an additional guide.

The heights of sensory damage corresponding to given cord segments may be seen at a glance from Fig. 54. Damage to nerve-roots is more apt to be irregular in distribution, but does not show itself very differently from that of the cord, save that cord pressure does *not* give pain of *radiating* type.

Differential Diagnosis.—Given a case with cord damage, the site of injury may be determined accurately and some idea may be formed of its extent. At or about the level of the damage there may be obvious deformity. In this region this may be fracture or dislocation: the

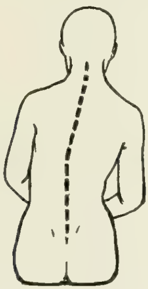


Fig. 67.—Lateral deviation of the upper spine *as a whole*.

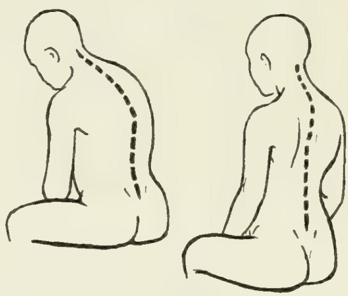


Fig. 68.—Anteroposterior deviation of the spine *as a whole*. The left-hand figure shows deformity in kyphosis; the other, a deformity in lordosis at the middorsal region.

dislocation is not to be differentiated from fracture at this level. There may be damage to the cord with simple distraction or from flexion with no spine lesion. Hematoma and local tenderness speak for bony damage. Abnormal mobility of the spine may mean either fracture or only extensive ligamentous tearing. Crepitus, rarely present, usually means fracture of lamina or arch, with or without fracture of the body. Fracture of the body (the usual type) does not give crepitus on moderate handling.

In default of cord damage nerve-root symptoms (*i. e.*, pain, paresthesia, anesthesia) may guide us as to the exact location, or we may have only local tenderness and lameness, with or without displacement.

Fracture of the body, as well as of the neural arch, may exist without any displacement that can be recognized. "Distraction" is recognizable only where *mobility* shows. Fracture of spinous processes alone may be shown by mobility of the fragment and by crepitus.

PROGNOSIS

Total cord lesions at this level *always* cause death. Patients die early from shock, from associated injuries, from pneumonia, from ascending myelitis, or later from the inevitable bed-sores or from ascending infection traveling from the bladder to the pelvis and to the kidney. Exhaustion and sepsis are usually the proximate cause of death. The fatal result may be postponed at times for many months. (See data

Fig. 69.—Fracture with mobility due to "distraction"—torn ligaments. Despite support, the deformity persisted. There were signs of root pressure for some weeks, and for some months weakness and abnormal mobility of the back persisted, but after a year he was apparently as good as new. This photograph was taken four months after the injury.

on Fig. 62.) Accurate prognosis seems impossible as to duration of life in a given case.

Partial lesions of the cord may become total from inflammatory involvement of parts not directly injured. As a rule, such cases tend to improve slowly, and often to a limited extent.

Nerve-root lesions usually recover entirely or almost entirely.

As to the function of the spine itself, apart from paralysis, full recovery of strength and mobility does occur, but is not the rule. The patient, if a laborer, is apt not to be able to perform heavy lifting, and

there is some lack of normal suppleness.* Some cases show considerable permanent weakness, and there are cases on record where considerable uncorrected displacement has resulted in a persistent mobility at the point of injury, such as to prevent the upright position save at the expense of great pain. This I have seen but once, and even in this case after a year this mobility was gone and the spine solid as ever (Fig. 69).

There is apt to be some deformity in the direction of a kyphosis, with or without some little lateral tilting. This interferes with flexibility and with the normal standing posture. At times the tendency of this deformity is toward increase.

In how far this increase represents the "spondylitis traumatica" of Kümmell† it would be hard to say. Undoubtedly, bone absorption under pressure does occur, with or without inflammatory process. In other cases yielding of weakened ligaments obviously plays some part.

Some of these unfortunate results are dependent on inadequate support of the spine after injury. It is certainly a fact that even in our best hospitals some cases of fracture without cord damage are overlooked, and that few of them are given adequate support or properly followed up.

TREATMENT

We may treat by simple fixation or fixation in extension, or we may precede these measures by forcible correction or laminectomy.

For purposes of treatment cases are divided into the paraplegic cases and the others.

Cases without Paralysis.—If there is no paraplegia, then forcible correction or open operation are only to be thought of to correct severe *obvious* deformity or to relieve *severe* pain from nerve-root pressure. In either case correction to approximately normal contour, with a minimum of force, is enough, with later fixation carried out in the way presently to be described.

If there is no tendency to kyphosis, in the simpler cases, simple

* I have had opportunity, by courtesy of Dr. F. B. Lund, to examine one case of almost complete recovery after dorsal laminectomy. He had some weakness, preventing heavy labor, but not more than in many unoperated cases.

† The condition known as "spondylitis traumatica," first described by Kümmell in 1891, is rather ill defined. It was supposed by him to be a progressive osteoporosis following trauma. In fact, the cases I have observed that might fall in this class seem to me to be flexion fractures—unrecognized and not properly supported. There is no doubt that such cases do show protracted and considerable disability, sometimes progressive. König held this to be the condition in spondylitis traumatica, and Wagner and Stolper (Die Deutsche Chirurgie, Lief xl, p. 244) recognize the occurrence of such lesions. Henle (Mittheil. aus den Grenzgeb. der Medizin u. der Chirurgie, 1895–96, H. 3), Kocher (*ibid.*, 1895–96, p. 448), Heidenhain (Monatsschr. f. Unfallheilkunde, iv, 3, S. 65), Vulpius (*ibid.*, iv, 7, S. 201), Kirsch (*ibid.*, iv, 5, S. 140), Schneller (Münch. med. Wochenschr.), Hettemer (Beiträge z. klin. Chir., xx, p. 103), and Bonsdorff (ref. Cbl. f. Chirurgie, 1900, No. 23, S. 1086) have all discussed this matter and reported cases. Grisel: Revue d'Orthopedie, 1907, p. 167, gives a more recent discussion.

fixation is enough; that is, fixation in bed with sand-bags, with a jacket to be applied later.

As a rule, however, we have to deal with flexion lesions, and, therefore, with a bony kyphosis. Consequently, if we do not wish or dare to reduce this kyphosis, we must prevent its increase. This must be done by fixation in the extended position. The patient lies on a Bradford frame, flat on his back, with hips and shoulders strapped to the frame. Opposite the kyphosis pads are placed (see Fig. 72) so as to support the spine, pressure being applied on either side of the spinous processes opposite the *prominent* vertebræ—usually the vertebræ *below* the break. Not rarely *full correction of displacement* as well as of general outline may be secured in this way.

Day by day the padding can be raised without discomfort until the desired correction is reached. Felt makes the best pads, but folded pillow-slips do fairly well (Fig. 72).

The patient can be raised, frame and all, so that he can be cared for without danger of disturbing the injured spine.

According to the apparent severity of the lesion, this treatment is kept up from three to six weeks. Then the patient is put up in a plaster jacket.

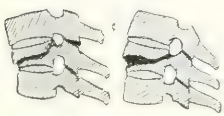


Fig. 70.—Action of hyperextension in opening up foramina in flexion fracture (dorsal).

In occasional cases the predominant symptom is extreme *abdominal* pain. This is sometimes accompanied by anesthesia or paresthesia at the level of the lower ribs or abdomen, and by *abdominal muscle spasm.** It occurs in some cases even where there is no obvious displacement. It is a sign of nerve-root pressure.

Occurrence of such pain is an *indication* for *hyperextension*, irrespective of apparent deformity.

This is because hyperextension relieves nerve-root pressure by opening up the foramina. Most, if not all, of these cases are flexion fractures. (See Fig. 70.)

All convalescent cases are to be put up in a plaster jacket.† This is to be worn at least six months. Repair of the spine is slow, and the normal strain on the dorsal spine is very great. Failure to support

* Differentiation between such cases and those other cases of trauma received in falls in which there is actual peritoneal damage is very difficult. I have seen four cases in which belly pain and abdominal spasm were enough to have led to exploratory laparotomy had it not been for knowledge of the occurrence of such pains due to spine fractures. These did well. If a case were to turn up with *both* spinal and visceral damage, it is hard to say on what our diagnosis would be based.

† The plaster jacket is best put on with the patient prone on a hammock frame so adjusted as to give proper lordosis, with felt pads incorporated in the jacket alongside the point of deformity to keep up the needed pressure (Fig. 73). In case a hammock-frame is not at hand, a very good jacket may be applied by putting it on in two sections, as shown in Fig. 74. Where expense is not a bar, a leather jacket (stiffened) is more comfortable and equally efficient.

such convalescent cases has, in at least three cases within my observation, resulted in great pain and unnecessary prolongation of disability.

Paraplegic Cases.—If there is *partial* paraplegia, we must make up our minds in each case whether the displacement present *at the time* is probably causing pressure on the cord. If we believe that it is, we are justified in operation, and all data tend to the conclusion that it is wise to operate in cases of reasonable doubt. The operation of choice is laminectomy.*

Laminectomy in expert hands is not risky, but it is difficult and is distinctly a surgeon's operation, not to be undertaken by the inexperienced operator, especially if his assistance be not of the best.

The object of laminectomy is four-fold:

(*a*) *Loose* fragments from the laminæ and arches may be removed.

(*b*) The laminæ of the vertebræ *next above* the point of injury may be removed.

(*c*) The dura may be opened, relieving tension from clot or from increased intrameningeal tension.

(*d*) With the operator's finger defining the position of the cord, forcible correction (by any desired means) may be more efficiently and more safely carried out than without incision.

Object (*d*) has been the controlling indication in several recent laminectomies of my own.

Except for certain neck cases, I am inclined to consider laminectomy *and* forcible correction the desirable combination.

Forcible correction *alone* applied to these cases is as old as surgery. Burrell and others have more recently advocated it. The only argument against it or against laminectomy is the lack of results. Rightly considered, we must look at spine injuries with paraplegia as ordinarily hopeless *without* interference. *Any* interference seems justifiable. Neither laminectomy nor forcible correction forms a cheerful field of surgery, but even the small minority of good results represent a gain over the hopelessness of cases let alone.

Traumatic cord lesions are *usually* total—that we cannot help;† what we can help is the abandonment of an *occasionl* case of paraplegia from simple pressure to a certain death, and neither surgeon nor neurologist can differentiate between these conditions in most cases. This is the justification of operative procedures.

Whether forcible correction is preceded and made simpler by lam-

*Laminectomy dates back to H. Cline (Tyrrell reported cases in 1822), and those inclined to look at this as a triumph of modern surgery will do well to read Cooper's Lectures (3d Am. ed., 1831, vol. ii, p. 15 ff.), in which he gives indications and contraindications that cover nearly all we can say today.

† Most surgeons accept cord damage already done as irremediable. The cases of apparent repair of cord structures given by Harte and Stewart (Trans. Amer. Surg. Assoc., 1902) and Fowler (Annals of Surg., October, 1905) have not yet received sufficient confirmation.

inectomy or not, the general manœuvers of reduction are the same: strong traction with direct pressure, aided somewhat in the open wound by direct traction on fragments with "lion" forceps or with retractors; direct pressure applied on the bone; and the occasional use of leverage with the "blunt dissector."

Forcible Reduction. In forcible reduction only two manœuvers seem to have been tried for luxations or supposed luxations without fracture:

Fig. 71. Case of low dorsal fracture with a properly applied plaster jacket, high on the chest, low on the pelvis.

(*a*) Traction upward upon head and axillæ, and downward on the legs, with direct pressure forward at the prominent portion of the spine. The patient, etherized, lies face down on a table.

(*b*) Traction as above, but with the patient prone over a barrel or the like, so as to bring about flexion. Combined with this, direct pressure is exerted on the prominent point.

(*a*) should be useful in anterior or posterior luxations of the usual types or in fracture luxations. (*b*) is devised for anterior dislocations. The flexion manœuvers should disengage the articular processes. Such luxations are rare.

Reduction in *fracture* cases has been, probably wisely, confined to manœuvers approximating those of (*a*).

One of the earliest modern papers advocating forcible rectification is that of Burrell.* He has since in a measure receded from the position then taken, but in a recent paper has reviewed 24 cases of spine fractures at the City Hospital mainly treated by this method.†

Laminectomy should be superior to forcible correction in case of fracture of the laminæ or arches; unfortunately, this class of cases cannot be diagnosed with any certainty.

* Med. Communications of Massachusetts Med. Society, 1887, xiv, p. 151.
† Burrell and Crandon: Trans. Amer. Surg. Assoc., 1905, xxiii, p. 66.

As stated above, forcible correction *after* opening the canal seems, on the whole, the wisest of the operative procedures.

After-treatment.—In paraplegic cases apparently hopeless the treatment is purely symptomatic, except for precautions to limit the almost inevitable bed-sores and bladder infection. Accurate fixation is difficult and not of first importance.

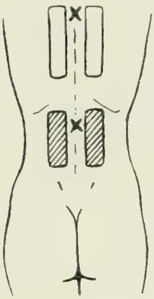


Fig. 72.—Diagram to show proper position of pads at either side of the spine, for dorsal or lumbar fractures.

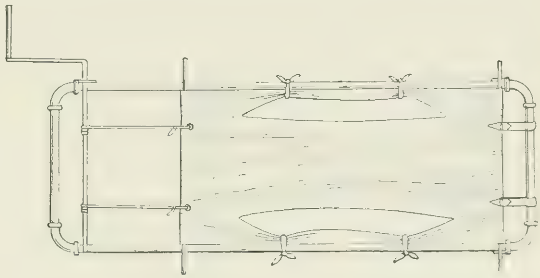


Fig. 73.—The Bradford frame for applying jackets in the prone position. The canvas sling is pulled taut, slits are cut along either side of the patient's body, the cloth tied back, and the apparatus is ready for use.

The Bradford frame is used, ordinarily, to facilitate handling in treatment, but the patient is not strapped down, and is rolled over as is needful to care for cleansing, for alcohol baths, and for any necessary dressings.* Such attempts as are made in such cases to prevent kyphosis are carried out with soft pillows or with shaped pads.

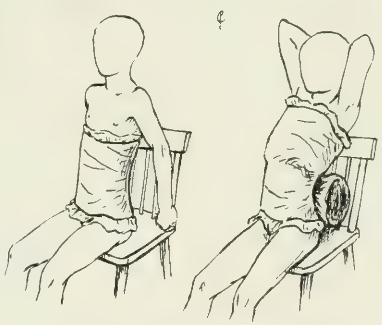


Fig. 74.—Hyperextension jacket applied in two sections. After the first section has set a pad is put behind it (a rolled sheet or the like) and the patient's trunk thrown back while the jacket is completed. This is a fair emergency method for dorsal injuries.

Passive motion of the limbs to minimize the formation of joint contractures is worth while in the event of possible recovery, and should always be carried out.

In all other cases than paraplegics our care is directed to fixation in as nearly as may be the normal position and curve; at first, by pads; later, with the jacket. As noted above, support is to be long continued, for fear of late absorptive changes.

* Dressings of a laminectomy wound are not very bothersome. The wound should not be drained. There is, for a day or two, a good deal of leakage of blood, serum, and some cerebrospinal fluid, but this soon ceases, and we get practically first-intention healing. The wound does not share with the parts further *below the fracture* the trophic effect that tends toward infection and sloughing.

The problem is one of fixation and support. At first we secure rest in bed with support by folded sheets placed on either side of the spine opposite the injury. After three or four weeks a plaster jacket may be applied.

The best method is by use of the Bradford frame (Fig. 73), but the schemes shown in Figs. 74 and 75 are simpler and may be made equally efficient.

Plaster jackets for dorsal cases should fit well into the axilla, should

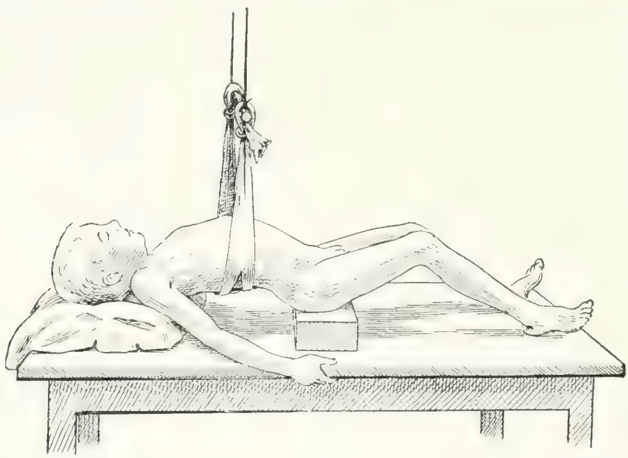


Fig. 75.—Sling device for putting on jackets with the patient supine. Readily arranged and efficient.*

come up nearly to the clavicle in front, and should come well down on the pelvis. (See Fig. 71.) They should be carefully padded, not only as shown in Fig. 72, but also over the sacrum and in front over the anterior superior spines.

Some cases require not only some months of jacket support, but also a steel back-brace (a spring-brace, as for round shoulders) to be worn during the latter part of convalescence.

* Drawn by the writer for the second edition of Bradford and Lovett, "Orthopedic Surgery," and used through the courtesy of the authors.

CHAPTER VI

THE LUMBAR VERTEBRÆ

LUXATIONS AND FRACTURE LUXATIONS

Pure luxation at this level is extremely rare: there is, in fact, some question about its occurrence. A glance at the almost interlocking articular processes in this region shows how unlikely it is that any pure luxation, even the theoretically possible backward luxation, should ever occur. (See Fig. 76.) Cases are recorded, but even the much-quoted case of Cloquet was, in fact, complicated with fracture.*

In one case of my own, operated on, there was obvious luxation, but there was enough deformity to make me sure there was also fracture,† though no fracture was visible in the wound. In practice it is even more true here than in the dorsal region that we should consider all cases clinically as *fracture* luxations.

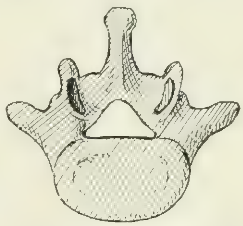


Fig. 76.—Lumbar vertebra from above, showing the direction of the articulating facets, also the relatively small spinal canal.

Fractures in the lumbar region differ from those in the dorsal mechanically, in that the lumbar spine lacks any lateral support from the ribs, hence displacement may be in any direction, laterally as well as forward or back. In fact, however, the greater strength of ligaments pretty nearly counterbalances this lack of rib support.

So far as etiology goes, we have a somewhat larger proportion of fractures from direct blows, or from twisting or crushing, simply

* This was the case of a roofer who fell off a house and was immediately paraplegic. Two years later, when examined, he had return of sensation and some motion. Postmortem examination, after death from unrelated causes, showed a backward displacement of the second lumbar vertebra on the right. There was flexion of the spine, as a whole, forward and to the left, and the right side of the second lumbar was, therefore, lifted as well as moved back. The total separation of the articular surfaces was ½ inch. There was *also a fracture of the arch and a little breaking of the left side of the body of the vertebra.*

† In this case laminectomy showed a clean forward luxation of the first on the second lumbar, with about ¾ inch separation on the right, and a little more on the left. There was partial crushing of the cauda. Forcible reduction was carried out by traction, backward pull, and rocking lateral movement; there was no crepitus. This patient is still improving, having recovered sphincter control in part, and is gradually regaining motion and sensation in the legs. The point is that, so far as I could demonstrate, this was a case of pure lumbar luxation. In my belief, however, there was in all probability an associated fracture.

because extreme *flexion* breaks the weakest point in the lower *dorsal* rather than the lumbar spine.

The bone lesions differ only in that the simpler flexion fractures are less common, while irregular displacements are more usual. Fractures of spines and laminæ alone are even rarer than in the dorsal region.*

Fig. 77. X-ray of normal lumbar spine.

So far as the clinical picture and the prognosis are concerned, we must take into account the relation to the spinal cord. The cord proper ends at the first lumbar vertebra; below this the canal contains not cord, but nerves—the cauda equina. Central lesions here are, therefore, *nerve* lesions, not *cord* lesions. In theory such lesions should be capable of repair, as cord lesions are not. In practice there is evidence of such readier repair in *partial* lesions, but not in complete crushing lesions.

Whether laminectomy *with nerve suture* will give better repair has not been tried out.

Injuries in this region, if complete, give sensory and nervous disturbances, as shown in Fig. 54.

DIAGNOSIS

Diagnosis in only too many cases is indicated by the paraplegia, and made more precise by determining the level to which motor and sensory disturbance extends.

Direct physical signs of displacement are: Deformity in the line of the spine, usually a kyphosis. Asymmetry of the spinous processes, which are fairly regular in the normal spine in this region. Crepitus or mobile fragments (rare). Displacement palpable through the abdomen (alleged in one reported case).

Indirect Signs.—Nerve-root symptoms, radiating pain, dependent on pressure not in the canal, but at the foramina.†

* A rare source of deformity in this region, sometimes *apparently* due to trauma, is the condition known as spondylolisthesis, a defective ossification of the laminæ of the lumbar spine, allowing a slipping forward of the column, with signs of nerve pressure. A good consideration of this, with bibliography, is to be found in Orthopedic Surgery, Bradford and Lovett, second edition, pp. 156–160.

† Here, as also in low dorsal lesions, the "girdle-pains" from root pressure, with

Local tenderness or signs of direct trauma.

In total lesions reflexes as well as voluntary motion are lost, but this does not help us in localization, as they are lost in *all* total lesions.

Differential.—In the differential diagnosis we must consider, if paraplegia is present, only the question of cord damage by hyperflexion with intraspinal hemorrhage, with or without bone damage. Lesions of this type are *rarely complete*. Local tenderness or other signs of trauma at the level of damage speak strongly in favor of bone damage. In the doubtful cases the far greater frequency of fracture luxation will

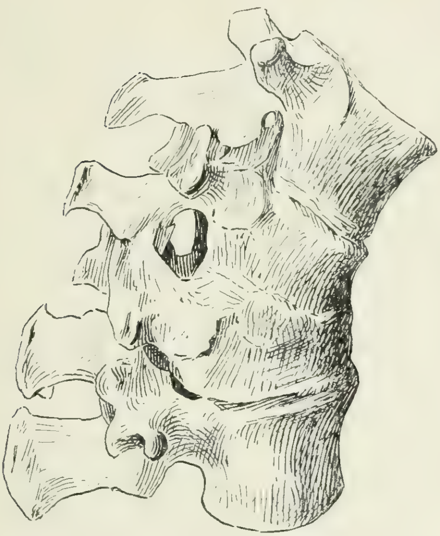


Fig. 78.—Fracture of lumbar vertebræ (Warren Museum).

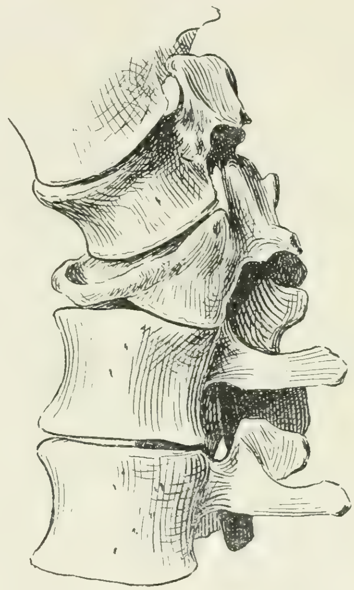


Fig. 79.—Crushing fracture of the twelfth dorsal and first lumbar bodies. Paraplegia. Lived nine months (Warren Mus., Spec. 941).

determine the provisional diagnosis, even if we cannot make out any displacement.

If there is no paraplegia, we must reckon with the fractures of spines, arches, and laminæ, with "distraction" injury, with the very common

the reflex spasm of abdominal muscles resulting, may give a picture curiously resembling that of rupture of a viscus or other belly damage, as in the following case:

A. B., aged thirty-seven. August 8, 1907, fell two stories. No cord symptoms. Main complaint was of *abdominal* pain. The abdomen showed marked general rigidity and spasm. Considering the presence of an obvious though slight deformity at the first lumbar spine, the apparent abdominal symptoms were disregarded. The girdle-pains (for that is what they were) were relieved by a hyperextension jacket. He was discharged September 17, and reported a couple of months later without symptoms.

"sprains" and "contusions" met at this level, and with certain localized neuroses. Isolated fracture of spine or lamina is even rarer here than higher up. In fracture of the spinous process we have soreness, mobility, crepitus, perhaps a little displacement, but no signs of damage to the column as a whole or to the cord.

Fracture of the lamina rarely occurs alone, and we have no way of diagnosing it, for even in the cases where there is crepitus without deformity, we cannot exclude more extensive fracture.*

"Distraction" injuries are pure ligamentous injuries, to be diagnosed when there is localized abnormal mobility in flexion, as when the patient sits up. We may safely say that in such a case there is a torn ligament. It is, however, often impossible to exclude *associated* fracture.

"Sprains" and "contusions" of the spine are very common from lifting, from falls, from blows. The signs are lameness and stiffness, with soreness to touch, usually over the erector spinæ muscle, *at the sides* of the spinous processes, most commonly close to the lower origins of the muscle. Even in genuinely severe cases there are no strictly objective signs, simply tenderness and "voluntary" spasm on attempted flexion. The pain and protective spasm are often extreme for a time. These cases must represent some stretching or tearing of muscle-fibers. Even in cases where there is no suspicion of malingering, there is apt to be a rather slow subsidence of lameness, lasting several months at times, especially in elderly or rheumatic patients.

In cases of tort, these injuries seem far commoner and worse than in hospital or private practice. I have never seen or known of *permanent* injury from such lesions in a case without a suit on hand, but there is no doubt that lameness may persist a long time.

Tenderness along the line of spinous processes may mean ligamentous strain or may mean nothing. If it is as great *at* as *between* the spines, or greater over the spines themselves, it does not mean such strain, in my opinion, but belongs to the curious "stigmata" of hysteric psychoses, as a rule.

PROGNOSIS

The prognosis of life in cases of lumbar injury with crushing of part of the cauda is good, on the whole. If there be a *high* injury involving paraplegia, we may have all the sequelæ of a cord injury except ascending myelitis. The lower the lesion, the less the damage, of course.

Lesions of the "conus," the sacral portion of the cord, involve anesthesia of perineum and genitals, and some disturbance of urination and of sexual power, sometimes with a persistent toe-drop.

It seems that the central part of the cauda and the conus are either more subject to trauma, or less able to repair damage, for persistence of the disturbance just described is not uncommon in cases damaged

* Sidney Lange reports a well-proved case (x-ray) of isolated fracture of the transverse process of a lumbar vertebra (N. Y. Med. Journal, Oct. 9, 1909).

well above the conus, in which paralyses, extensive at first, have retrograded to this point.

The general prognosis of repair in the cord and nerves in this lumbar region may fairly be called hopeful, if the cord is not actually crushed; but it is not reliable, not better than hopeful.

So far as the repair of the supporting function of the spine goes, the results are fair in lumbar injury. There is, as a rule, some stiffness of the segment involved in the injury, and some weakness at least for a long time after. In some cases there may be kyphosis enough, due to actual bone displacement, to interfere with standing readily or continuously, and consequent inability to do various sorts of work. Disability is, however, rarely due to bony displacement as such.

TREATMENT

If there is even a *question* of relievable pressure, laminectomy is the procedure of choice—safer in this region, probably, than forcible correction and far better surgery.

One of the chapters in surgery yet to be written is as to the results of nerve *suture* in the cauda. Theoretically, at least, it should be of value, and certainly it should be tried. Ordinarily, relief of pressure is all that is attempted.

As to treatment: beyond open incision, we can only fix the spine in approximately normal profile, exactly as we do in other segments. In the after-treatment we must bear in mind that this segment of spine has no support of ribs, etc.,—no support, in short, except such as we give it,—and that its normal position is in lordosis. It is, therefore, wise to give pretty definite support—that is, to place on either side of the spinous processes, opposite the more prominent segment (*i. e.*, usually the part below the fracture), fairly heavy pads (folded sheets or felt pads) to maintain the proper position.* Symptoms showing pressure on nerve-roots in the foramina call for *exaggerated* lordosis, which gives marked relief by easing this pressure. Support is perhaps even more important in cases without than in those with paraplegia, and must be continued in the plaster jacket appropriate to convalescence, which must be applied in lordosis and must be so padded as to maintain this lordosis without pressure on the spinous processes, and without pressure anywhere on that part of the spine which has been displaced forward.

In the cases of distraction, etc., all we need concern ourselves with is the matter of position (*i. e.*, lordosis), maintained until the ligaments have had full time to heal. In the lumbar region, perhaps even more

* Particularly in the lumbar region, *slow* reduction by gravity succeeds very well. At times counter-pressure by sand-bags or pads alongside the projecting spines gives astonishing results.

than higher up in the spine, support should be continued for a long period—several months at least.

Muscle Strain.—A word as to treatment of the simple *muscle* strains in this region may be worth while. Firm strapping with adhesive plaster gives astonishingly efficient relief in the early stages. Later, massage, heat, and the treatment by electric high-frequency currents are most helpful. Fixation by strapping or otherwise should not be long continued. Bed-rest is rarely called for after a few days. Despite the best treatment a *little* lameness is apt to persist for a good while.

CHAPTER VII

THE SACRUM AND THE COCCYX

SACRUM

There are no luxations of the sacrum.* As a result of direct violence there occurs, though very rarely, an approximately transverse fracture of the sacrum. The displacement is of the lower fragment forward. Other fractures are complications of damage to the pelvis, treated under the caption of Pelvic Fractures.

Diagnosis is by mobility and crepitus elicited on bimanual examination with a finger in the rectum. Pain on cough or on other muscle action is suggestive.

There may be, of course, damage to sacral nerves emerging at the level of fracture, or crushing in the canal of those emerging lower down. There may be damage to the bladder or rectum. There seem to be no data that give any accurate idea of prognosis.

Cases of lesion of the sacral cord, untreated, give a tolerable result, with some loss of urinary control and sexual power, with some anesthesia, and sometimes with a paresis of the lowest segment group of the leg (*i. e.*, with a toe-drop). The bony lesion *as such* appears to be of no importance.

Treatment.—As to treatment, obviously reduction by the finger in the rectum is desirable and indicated. For prevention of redisplacement we have no facts bearing on the problem. Paul† has made the interesting suggestion that Malgaigne's hooks or a modification of them might be used. Packing of the rectum has been suggested and tried.

In this region laminectomy, with relief of pressure or with performance of nerve suture within the canal, seems to be proper surgery. I have had no chance to try suture of nerve-trunks, and do not know of its being done, but it is obviously justified where there is damage to the nerve-trunks of the conus. There is no possible reason why the sacrum should not be cut open to clear away pressure in its canal.

COCCYX

Lesions of the coccyx are rather common. In part they represent actual fractures or luxations. In still larger part, unfortunately, they

*Unless we count those occurring as part of general pelvic damage—with other fracture or luxation of the pelvic ring—or the "sacro-iliac" strain and subluxation cases.

†T. W. Paul: Ann. Surg., *loc. cit.*

represent hysteric disturbances *not necessarily* connected with even slight trauma in this region.

The coccyx may be broken between joints, or one or another joint may be luxated. Such *actual* injuries result from direct violence only.*

The case illustrated in Fig. 82 may be taken as illustrative of the *genuine* class. This was the case of a healthy woman of twenty-six, who fell from a step-ladder so as to strike her coccyx fairly on the back of a chair. She was laid up for a time, and never fully recovered during the two years before she was operated on. Excision of part of the coccyx (Fig. 82) entirely cured her.

The importance of operation on such cases is twofold: first, the relief of pain; second, avoidance of the interference with the obstetric difficulties of a fixed coccyx in later childbirths of the patient.

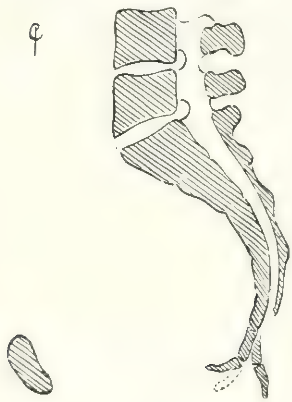


Fig. 80.—Diagram of forward and backward displacement of the coccyx. The dotted line shows the normal position.

Fig. 81.—Method of palpating for deformity or tenderness of the coccyx. Diagrammatic sagittal section.

The patients seem to be, in the rule, young women.

The case above quoted is the only case of the sort I have operated on for years, out of a considerable number seen.

The coccygeal region is the center of a curiously sensitive nerve plexus. Most of the cases seen, even when there is a history of some injury, are essentially localized symptoms of a psychosis, "hysteric,"

* Trauma to the coccyx does not necessarily involve a blow from a pointed object; a fall on stairs when the patient slides down in a half-reclining, half-sitting position may give *direct* trauma of the coccyx, and often does, though until one examines the skeleton it seems impossible.

as we name these localized psychoses. In such cases operation will not help the patient and will only discredit the operator.

In the absence of *definite* physical signs it is well to be skeptical as to operative prospects, even in cases where the rectal, as well as the external, surface of the coccyx is tender to the touch.

Diagnosis is made by physical examination, with but little regard to the given history. Physical examination is best made with the forefinger in the rectum, the thumb on the external surface. (See Fig. 81.) In this way the whole coccyx can be palpated, and any irregularity, any preternatural mobility or loss of mobility, may be appreciated. Some loss of mobility in the various joints in the adult, and some irregularity, are within normal limits.

Any possibly reducible displacement in a fresh case would, of course, be corrected *immediately*.

These cases are apt to come to the physician for help long after the injury. Such injuries give little ecchymosis and little crepitus even when fresh, but if fresh, the tenderness is so much more extreme on motion involving one or another point, and deformity or increased mobility is so obvious, that diagnosis is pretty definite. In these fresh cases walking or any motion that brings strain on the pelvic *muscles** is very painful.

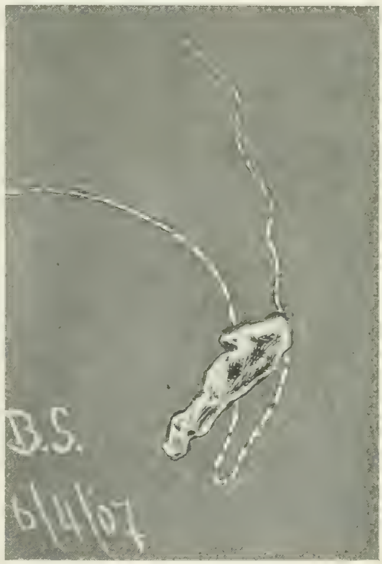


Fig. 82.—Specimen of coccyx removed by the writer. Dotted lines show the normal outline and relations.

Treatment.—Given a definite fresh case of injury, we should enjoin absolute rest for a week or two and protection from pressure until the tenderness is all gone. Such protection is well cared for by one of the large inflated rubber-ring cushions to be used while the patient lies or sits down.

Such rings are a very useful palliative in the chronic non-operable cases, including those in which old trauma probably plays no part at all, or at least a very subordinate part.

*It must be borne in mind that the coccyx is one of the attachments of the levator ani, a muscle that is constantly pulling and being pulled on.

CHAPTER VIII

THE STERNUM

LUXATION OF GLADIOLUS ON MANUBRIUM

This injury is not extremely rare. It occurs from direct violence to the front of the chest, from forced flexion of the trunk, from forced extension under muscular pull (hence occasionally from simple muscle strain, as in lifting, or in rare cases in childbirth).

The manner of its causation usually explains the displacement in the given case.* As a rule, it is the upper portion that is more likely to be struck and driven in. (See Figs. 83 and 84.) The overlapping is necessarily slight, owing to the resistance of the attachment of the ribs.

Fig. 83.—Separation of gladiolus foreward from manubrium. (Warren Mus.) Note intact periosteum.

Pathology.—The anterior ligament is usually torn clean across. According to evidence from specimens, and according to the inference from clinical data, the periosteum at the back seems to strip up rather than tear. Obviously, there may be greater displacement, with mediastinal damage,† but in the usual cases where the chest is not actually smashed in, this periosteal flap is seemingly an adequate protection for the structures behind it. (See Fig. 83.)

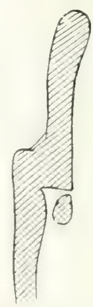


Fig. 84.—Median section, specimen of sternal luxation. This is the usual direction of displacement (after Gurlt's plate).

The luxation may be a clean dislocation, or the separation may run in part through the joint, in part as a fracture.

Diagnosis.—The diagnosis is ordinarily obvious, and to be made by direct palpation of the projecting bone. The joint is, of course, exactly

*In a case reported by me in conjunction with Dr. J. S. Stone (Boston Med. and Surg. Jour., 1897) there was a driving *in* of the *gladiolus*. The patient, a tall, long-necked, long-chinned gymnast, had slipped in doing the "giant swing" and had fallen on his head, with his neck extremely flexed, so that his long jaw struck the gladiolus and drove it in behind the manubrium.

†Gurlt quotes two cases where mediastinal bleeding was perhaps the cause of death, and says that the pleura may be torn open.

opposite the second rib. There is ordinarily little hemorrhage or swelling within twenty-four hours.

The only chance of error is that we find in some individuals a considerable projection at this point, an exaggeration of the usual "angle of Louis," which might impress the unwary as abnormal.

Prognosis.—The injury does little damage—even the soreness is not great. There is a perfectly definite tendency for the displacement to be reduced spontaneously by any sudden muscle action, as in coughing. Even if reduction does not occur, the resulting disability is slight.*

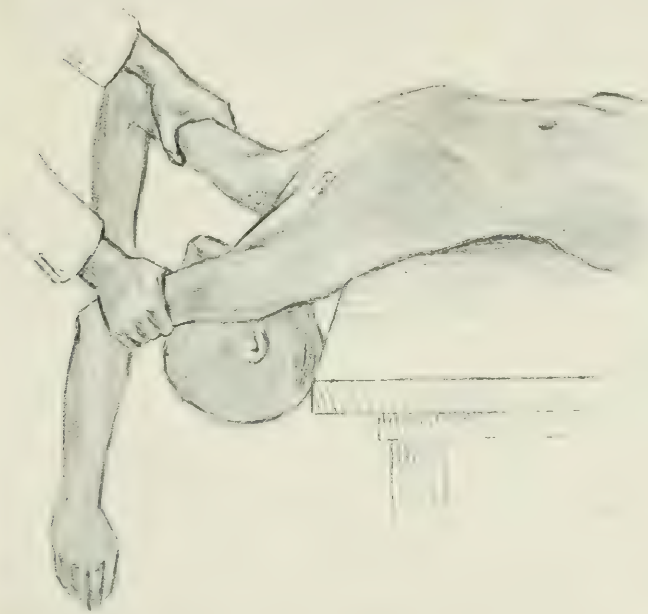


Fig. 85.—Reduction of sternal fracture or dislocation. Author's method.

Treatment.—Reduction depends mainly on favoring muscle action—therefore general anesthesia is not desirable for the ordeal.

The ordinary method is to place the trunk in hyperextension, and then to let the patient cough repeatedly. The operator helps by pushing on the projecting fragment.

My modification of this method† depends on the fact that the origin

* Since this paragraph was written I have had opportunity to examine such a case of typical unreduced luxation of the gladiolus forward, about a year after the accident. There was no disability at all referable to this injury.

† First employed in 1895; published in the Boston Med. and Surg. Jour. in 1897, *loc. cit.*

of the pectoralis major is largely from the manubrium. If, therefore, the patient is hung over the end of a table with hips and loins supported, with the trunk sharply hyperextended; if, then, the arms be held raised and abducted and the patient required to contract the pectorals strongly (Fig. 85), he is in better position to profit by his own efforts in coughing and by what the surgeon may effect through counterpressure.

After-care need consist only of cross-strapping of the front of the chest with adhesive plaster. The tendency to recurrence is practically negligible. To guard against irritation and possible prolonged soreness, any heavy work should be avoided until the lameness has gone.

FRACTURE OF THE STERNUM

Fracture may occur, as has been said, close to or into the joint; fracture in various lines through the gladiolus at any level is not rare; the accompanying plate shows the lines of fractures illustrated in the collections of the Warren Museum. These fractures are rather rare, except as a part of a general and fatal crushing of the chest. They may occur, however, as a "contrecoup" in falls on the back or side.

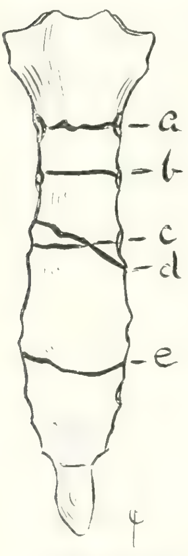


Fig. 86 Sternum fracture from specimens in the Warren Museum: a = Spec. 5149; b=978 and 5151; c=5150; d=976; e=977.

Their recognition depends on the presence of localized tenderness and possible slight deformity from displacement. Later, ecchymosis is evident. Curiously enough, this fracture is practically never compound.

The treatment is usually by fixation only. Displacement, if present, may call for reduction, as in true luxation.

DISLOCATION OF THE ENSIFORM CARTILAGE

This is a rare and curious accident. The dislocation seems always to have resulted from a direct blow. The displacement is of the ensiform,—backward; the line of separation may be through the joint between the gladiolus and ensiform, or there may be fracture of the ensiform cartilage itself.

All real knowledge in regard to these injuries dates back a generation to the German surgeon Gurlt. He described certain cases in which persistent, continuous, or recurrent vomiting resulted from the backward displacement of the process. One of these cases was relieved by digital correction of the displacement, another by lifting the process forward with an inserted hook.

Apparently there is no question that the vomiting in these cases was due to the displacement; it ceased with the correction of the displacement.* Probably not all such cases give these symptoms.

There seems to be no inconvenience from either fracture or dislocation, reduced or not, except when the vomiting above mentioned occurs.

It is said that fractures of the ensiform give fibrous, not bony, union.

Diagnosis.—The recognition of this lesion should not be difficult, inasmuch as the process is almost subcutaneous, and any displacement should be easily palpable.

Treatment.—Obviously, replacement of the fragment driven backward should be the object of treatment. If this can be done by manipulation,—and ordinarily the finger may readily be hooked under the end of the process,—this is enough. If this method does not work, and if the symptoms warrant it, open operation would be called for. It should be possible to get a grip on the process without entering the peritoneal cavity, though in Gurlt's case the peritoneum was opened.

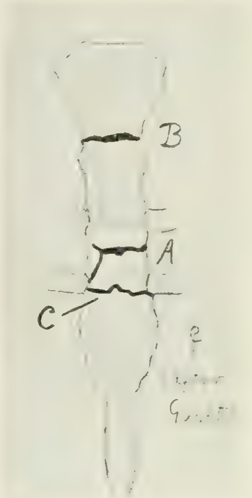


Fig. 87.—Sternum dislocation and fracture (after Gurlt's plates).

After-care.—Save for immobilization of the lower chest as a whole and for rest, it is hard to see how any treatment would help.

Prognosis.—Save for the (reflex ?) vomiting there seem to be no sequelæ. Ordinarily, not even weakness is left behind after either fracture or luxation.

* It is rather curious that the occurrence of such symptoms has not been repeatedly and recently confirmed, but there seems no question of the fact. Gurlt's data were usually reliable and well sifted.

CHAPTER IX

THE RIBS

DISLOCATION OF THE RIBS ON THE VERTEBRÆ

This is a very rare accident, hardly occurring except in the case of the lowest ribs—the floating ribs; if it occurs higher up, it is in association with damage of the transverse processes of the vertebra. It seems to occur only as the result of direct violence.

To produce this sort of dislocation there must be a tearing not only of the ligaments between the articular end of the rib and the vertebral body, but also a tearing of the strong ligaments that unite the rib to the transverse process.

Fig. 88.

Cases are described presenting various displacements—there seems to be no definite rule.

Diagnosis.—The diagnosis rests on a disappearance of the normal prominence of one of the series of ribs close to the vertebra. Just what has happened in the individual case is a matter of inference. There are no special symptoms, save the lack of crepitus, to help us make the diagnosis of dislocation as against fracture near the back end of the rib. In the one case of this sort of injury in my experience it proved that we were concerned with a fracture, and not a dislocation, but previous to the taking of the x-ray all that we knew of the matter was that there was a forward displacement of the rib on the vertebra, shown by the absence of the normal resistance at this point in the back. There are no pathognomonic or trustworthy symptoms.

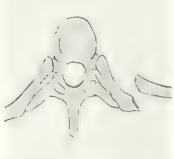


Fig. 89.

Fig. 88.—Luxation of rib from vertebra (schematic).

Fig. 89.—Fracture of rib close to the vertebra (schematic).

Complications.—Curiously enough, considering the proximity of the kidney, there seems to be no tendency to any associated injuries of the soft parts. This is probably because the violence acting on the one rib is checked by the resistance of the other ribs.

Treatment.—No treatment seems to have been carried out in any of these cases. From the very nature of things only two forms of treatment would be worth considering—operative interference, which is not called for, and attempts to reduce the dislocation by having the patient strain or cough. Direct manipulation is obviously impracticable, at least in case of forward displacement, unless through an incision.

Results.—Apart from such natural lameness as would be associated with the violence, the injury seems to give no trouble. From a practical point of view it may be called hardly more than diagnostic curiosity, whether the lesion be a luxation of the rib or a fracture near this point. The unreduced rib seems to give no permanent trouble.

DISLOCATION AND FRACTURES OF THE FRONT END OF THE RIB

Dislocation here may occur as a separation of the cartilage from the sternum, as a separation of one cartilage from another at a level below the sternum, or as a separation of the rib from its own cartilage at the costochondral joint. Fractures may also occur *across* any of the cartilages themselves.

The differential diagnosis as to the form of injury—whether separation of rib from cartilage, fracture of cartilage, separation of cartilage from sternum or of cartilage from cartilage—is purely one of anatomy.

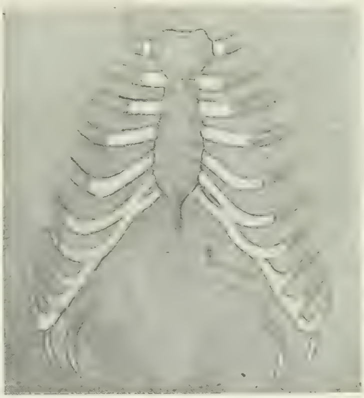


Fig. 90. Anatomy of ribs and cartilages: the cartilages are shown in white.

There is no fixed relation between the length of cartilage in front and the length of the rib. In general, we may say that the cartilage length increases from a mean of about $1\frac{1}{4}$ inches at the first rib to about $3\frac{3}{4}$ inches at the level of the sixth, with a maximum of $5\frac{1}{2}$ inches of cartilage at the level of the eighth. Below the sixth rib the cartilages are attached, not to the sternum directly, but to the cartilages of the ribs above. Ribs eleven and twelve have no such attachment, and are called, for this reason, "floating" ribs. (See Fig. 90.)

Any lesion in this anterior region is localized by deformity, or in default of deformity, by local tenderness.

The diagnosis in detail is then made purely on the exact *position* of our findings.

Cartilage Separation

The commonest of these injuries is a partial or complete separation of some cartilage between the sixth and the tenth from the one next above it of the cartilages which form the arch of the epigastrium.

These injuries may result from direct violence, from crushing in of the chest, or from a simple blow or fall so received elsewhere on the rib as to be transmitted to this point.

Diagnosis depends on localized tenderness with considerable soreness

on movement and with some pain on breathing. We may have some local deformity, and sometimes there are cases in which breathing or coughing or manipulation gives a soft click distinctly to be felt by the hand. Later there is thickening, irrespective of original displacement.

Treatment.—Any displacement present should, of course, be corrected, and in this region it is ordinarily possible to get hold of the rib cartilage at the epigastric end.

Further treatment consists of simple immobilization of the lower part of the chest. The lower ribs may be immobilized by a broad band of adhesive plaster encircling the chest below the nipples. A half swathe applied to the injured side and running across the whole front of the chest may be sufficient. The purpose to be followed is such immobilization as will render the injury practically painless on breathing, and limit any motion of the separated surfaces.

Results, so far as deformity is concerned, are good. In some cases there is a little thickening persisting for a while, more rarely for a long time. In others the callus formation is almost nothing. Owing to the slow repair, the spot often remains sore on physical exertion for a good many weeks. There is no permanent damage, but the accident entails a period of partial disability apparently disproportionate to the original damage.

Separation of the Ribs from the Sternum

This is a relatively rare accident, usually the result of direct violence or of crushing of the chest. The displacement of the cartilage may be either forward or backward. The displacement may be considerable, but is seldom more than enough to allow simply a slight overlap one way or the other. Except for the local tenderness, the slight deformity, and the occasional soft crepitus on respiration or cough, there are no special symptoms. Practically, diagnosis rests on palpation; in the absence of displacement, on tenderness.

Treatment consists of attempts, by way of forced respiration or cough, combined with direct pressure, to reduce the displacement. If this is successful, immobilization of the chest by cross strapping is all that is required. If replacement is not practicable, the displacement may persist with slight local deformity, but without permanent damage, at least in cases where the injury is of *one* rib-joint alone.

Fracture of the Rib Cartilage

Fracture of the rib cartilage itself is not very rare, and may occur with any rib, most often, of course, with one of the lower "true" ribs. The cartilage fracture is usually transverse or nearly so. There may be a displacement or displacement of either fragment in front of the other, sometimes with overlapping.

Diagnosis rests on the site (anatomically), and not on the character of the signs.

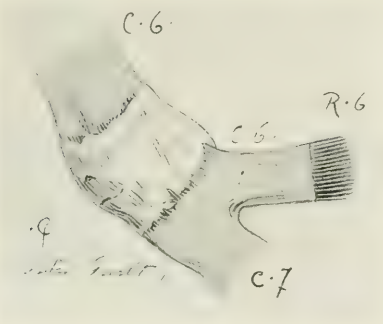


Fig. 91.—Shows the bony collar surrounding the fractured rib-cartilage (R. 6, sixth rib; C. 6, C. 7, sixth and seventh cartilages). Wilms' specimen (from Gurlt's Fig. 20).

Fig. 92.—Horizontal section of united fracture of rib-cartilage. X and Y show the masses of new *bone* (sketched after Gurlt's Fig. 24. Specimen in the Mus. Path. in Giessen).

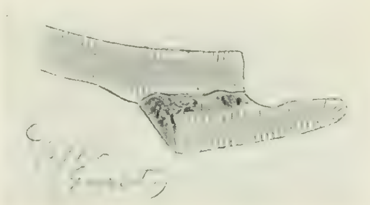


Fig. 93.—Union in fracture of rib-cartilage. Horizontal section, drawn from Gurlt's Fig. 22. (Specimen in the Path. Mus. at Giessen—No. 35–114a.)

Replacement is by manipulation, aided by sudden muscular movement (*e. g.*, coughing) on the part of the patient.

After-treatment differs in no way from that of the other injuries treated in this chapter, nor is there any essential difference in prognosis. Of some interest is the fact—admirably expounded with illustrations from museum specimens by Gurlt*—that the cartilage ends unite, not by fibrous tissue or cartilage, but by a rather spongy bone which usually forms a bony collar about the ends of the broken cartilage, which are almost unchanged, even under the microscope. He lists 15 cases and specimens, and gives five very satisfactory plates to prove his point. (Figs. 91, 92, 93.)

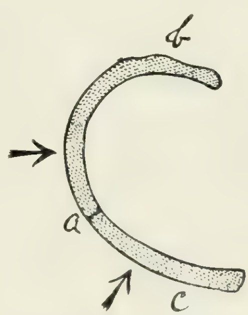


Fig. 94.—With a fracture or displacement at *a*, there will not only be pain on pressure at *a*, but pressure at one side or the other—at points noted by the arrows—will give pain at *a*. So, too, will compression exerted in the line *b c*. If there be only contusion or periostitis, pain is excited only by direct pressure at *a* or by muscle action.

*E. Gurlt: Handbuch der Lehre von den Knochenbruchen, 1865, Bd. ii, 1. Th., pp. 244 ff.

Dislocation of the Rib from the Cartilage

Costochondral Dislocation.—This is a more common accident than either of the last two. Between rib and cartilage, up to middle life or later, there is a distinct joint possessing only a little play, but possessing also little strength of ligaments. Under the influence of direct or indirect violence these ligaments are torn, and according to the direction of the force the rib overlaps the cartilage, or the cartilage the rib, producing a distinct displacement. Not uncommonly several of these

Fig. 95.—Separation of ribs 2, 3, and 4 from their cartilages with luxation backward. Injury received by being rolled between two cars. Operation: pinning; perfect result.

joints on the same side are displaced together. The direction of displacement will then be the same in each.

Diagnosis.—There is no difficulty in diagnosis, as the injury gives rise to distinct displacement, usually without any considerable swelling or ecchymosis to obscure the contours. (See Fig. 95.)

Treatment.—In this form again the treatment consists primarily of an attempt at reduction by coughing. Hyperextension of the trunk may also help. If in this fashion reduction is accomplished, the tendency to displacement is slight, and the strapping will be sufficient protection. If this reduction fails, there is a possibility that after the relaxation of

muscular spasm spontaneous reduction will take place. If it does not, we have no resource except the choice of open operation or of allowing the displacement to remain.

The results of this dislocation are comparatively good, even if it is unreduced. The deformity remains, but the permanent damage consists only of a slight weakness of the chest in heavy work. There is no tendency to visceral complications. If, as usually happens, the injury is the result of crushing, the viscera are either fatally squeezed at the time, or they are sufficiently protected by the elasticity of the ribs. We have here no sharp points, as with rib fractures, to injure the heart or pleura or lungs. Operation may be performed as in the subjoined case.

Case.—Bell; freight conductor; "rolled" between cars; showed a good deal of shock, from which he recovered promptly. Examination showed fracture of the right clavicle, and the second, third, and fourth ribs loosened from their respective cartilages. (See Fig. 95.) Second rib not displaced; third and fourth displaced inward and backward behind the cartilages, from which they had been torn away. The third rib on the left was similarly displaced. The left acromioclavicular joint was dislocated, with moderate displacement.

Owing to the man's somewhat weakened general condition and to the existence of a chronic bronchitis, operation was postponed. In the meantime attempts were made to induce a reduction of the ribs, by hyperextension of the trunk, by getting the patient to cough, and by supplying suction traction to the ribs. These trials all failed. The man suffered little pain, showed no reaction on the part of the lungs, and no difficulty with breathing, but the second and third ribs on the right were pulled inward with every inspiration. As this mobility did not decrease and promised anything but a strong chest, operation was decided on, and was performed under ether nine days after the accident. An incision was made from the middle of the sternum outward along the third rib. The articular end of the rib cartilage was found smooth and undamaged. About an inch outside the cartilage the periosteum was incised, and the rib encircled with the periosteal elevator and retractors, as if for a rib excision. A strong pull upward and outward was then applied, with counterpressure over the sternum. Reduction in this way proved impossible. The end of the rib was then cut down on and freed by blunt dissection, and lifted up in place by direct leverage, with a Spencer-Wells blunt dissector. It showed no tendency to remain in place, but slipped indifferently back or in front of the cartilage. The cartilage was then drilled in a line running from the sternal end to the middle of the articular surface, from which the rib had been dislocated. A strong needle about 3 inches long was then passed through this drill hole and driven about $\frac{3}{4}$ inch into the rib, while the rib was held in its proper position. The skin incision was then sutured. A like incision was then made over the fourth rib, and it was similarly reduced. In this case, however, manipulation did not fully reduce the displace-

ment, as the cartilage had been partly torn loose from the sternum and twisted out of place. An attempt was made to pin this cartilage in place, but abandoned on account of the mobility of the torn cartilage. The tendency to displacement here was less, apparently because of the nearness of the intact fifth rib. The second rib showed some mobility, but no displacement at the joint, and was let alone. There was strikingly little hemorrhage during the operation, and almost no ecchymosis resulting from the operation or from the original injury. A wiring of the acromion dislocation was done at the same operation. Recovery from ether was good, and following the operation there was not only no discomfort from the pain, but the man felt more comfortable than he had before.

April 2d the dressing was taken down for the first time, the temperature having been normal, and not only the third, but the fourth, rib was found to be in place. The second rib, curiously enough, seemed to have suffered some displacement of the rib backward. The needle had caused almost no irritation and was not removed. Patient sitting up and comfortable.

The needle was removed on the tenth day; there was no recurrence of displacement, and on the twentieth day the patient left the hospital apparently cured.

Subluxations of the Costochondral Joint

These are far commoner than total dislocations, and their occurrence is particularly associated with heavy muscular strain during adolescence. Not uncommonly they occur as a result of gymnasium work or games on the part of girls of only moderate physique. In other instances they occur from the same sort of violence as would produce a total dislocation were the force greater. In either case we have tenderness and lameness referred to this point on one single rib, and associated with well-marked tenderness, and, ordinarily, with some thickening. It is fair to assume that, at least in the distinctly traumatic cases, there has been a temporary displacement, but when we see the cases, this displacement is no longer present.

Treatment consists, not of reduction—for there is nothing to reduce—but of fixation by strapping of this portion of the chest, and of rest of the corresponding arm for a considerable time, at least for a fortnight.

Later, massage will assist the union and minimize symptoms.

Here, again, the results often seem disproportionately great in proportion to the actual injury. The joint is apt to remain a little thickened, a little tender, and a little lame on the use of the arm, and this condition may persist through months, causing a comparatively slight but very troublesome disability. Apparently stubborn as this trouble is, there is never any permanent damage unless we reckon the thickening, which is apt to persist.

CHAPTER X

THE CLAVICLE

DISLOCATIONS OF THE CLAVICLE

The function of the clavicle is essentially that of a "strut" which holds the arm and scapula away from the body. In this function it is unsupported, and must bear the force of any blow that tends to drive the shoulder inward or forward, and must to some extent withstand the strain of any blow from above, or of any strain tending to pull the arm downward. For this reason, as well as on account of the exposed position of the bone, it is frequently damaged. The usual lesion is, of course, a fracture. Blows on the shoulder from the front usually break the clavicle. Blows from above may break it, or, if they strike far out, they may dislocate the outer end. Blows from behind are apt to break the shaft or to dislocate the inner end. Extreme extension of the arm backward may dislocate the inner end by leverage across the first rib.

Dislocations of the Inner End

Total dislocations of the inner end are rare. They may occur in any direction, including the dislocation behind the sternal notch.

This particular dislocation is important because of the fact that the displaced head may encroach upon the vessels as they enter the mediastinum,* and may produce considerable disturbances of circulation and respiration.†

Fresh dislocations are readily reducible, whatever their direction, by traction and manipulation. The difficulty is not in reduction, but in maintaining the reduction. The condition after reduction is not essentially different from that obtaining in the subluxations, in which the

*Such encroachment may not occur or may have no practical bearing. A case recorded in the City Hospital under Dr. M. H. Gavin's care in 1891 showed backward dislocation not only of the clavicle, but of the first rib as well, without special symptoms of this sort.

The only case I have examined must have had some such encroachment, but showed no trouble from it at all, and not even any prominence of the neck veins of that side.

†Slaughter (Amer. Med., March 3, 1906, vol. xi, p. 30) records a case in which a steeple-chaser fell and sustained an upward and backward luxation of the inner end of the clavicle. Unless held down by the fingers, the head rode up and pressed on the trachea, giving a sensation of choking. An open operation was done, as it was found impossible to maintain reduction.

At operation all ligaments were found torn. A suture of kangaroo tendon through the end of the clavicle and the sternal ligaments, with a drill pinning the clavicle to the sternum (removed at ten days), brought about a perfect result.

ligaments are sufficiently retained to prevent very great displacement. In either case we have the problem of a joint in which the contact with the sternum is of small area, and in which the strains of ordinary use are more or less tangential to the joint surface. There is nothing to maintain the position of the joint save the ligaments, and it is just these ligaments which have been severely torn by the injury and cannot be depended upon for retention.

This luxation may be up, down, in, or in and backward into the upper strait of the chest, into the entrance to the mediastinum.

In all forms save the last the diagnosis depends on palpation of the sternal end of the clavicle in other than its normal place. In dislocation *behind* the notch we have simply a disappearance of the inner head, ordinarily palpable, and some restriction of shoulder motion. The classic picture of interference with respiration, venous congestion about the head, etc., is not necessarily present.

Either in fracture near this joint or in luxations the existence and direction of displacement are to be made out not only by examination of the sternal notch, but by following the subcutaneous upper surface of the clavicle.

Subluxations

The diagnosis of the subluxations is not difficult, and the fact that they are sometimes overlooked is usually due to the fact that injuries to this joint are very frequently combined with other more obvious injuries, such as fractured ribs, etc. In the subluxations we have localized pain on motion, localized tenderness, and some deformity of the sternal notch on the injured side as compared with the other.

In the total luxations the diagnosis is ordinarily obvious, and even in the subluxations, it is comparatively easy. The only question is between the dislocation and fracture close to the sternal end. In the presence of swelling the differentiation presents some difficulty. It is by comparison of this side with the other side of the sternal notch that we must reach our conclusions. This comparison is made by touch, not sight. A fracture near the sternal end of the clavicle may give some tilting upward of the outward end of the inner fragment, and some deformity, but deformity to an extent trifling compared with that of the real dislocation. Shortening measured from the acromion to the middle line *may* give valuable evidence of injury, but is common to the dislocations and to the fracture, while an accurate determination of a point on the middle line to measure from is hardly possible.

REDUCTION AND TREATMENT

For upward dislocation we need do no more than press the clavicle down, the shoulder up, and immobilize the arm in a sling, while the

inner end of the clavicle is strapped down, with a pad over the bone.* (See Fig. 96.) This strap and pad are common to all the forms.

Downward luxation calls for backward traction on the shoulder and

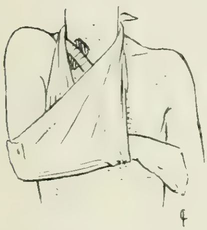


Fig. 96.—Treatment of upward luxation (the usual form). Clavicle held *down* by a pad and a strap of adhesive. Arm and shoulder are held slung *high up* in a sling.

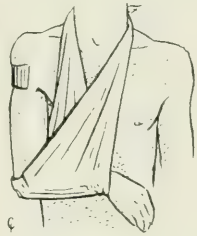


Fig. 97.—Treatment of luxation downward after reduction. Backward traction and a sling.

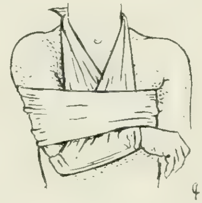


Fig. 98.—Treatment for outward or forward luxation; sling and circular with the whole arm adducted.

retention of the shoulder in this position by a sling and by adhesive strapping (see Fig. 97) or a figure-of-8 dressing.†

Outward and forward luxations call for reduction by *adduction* of the whole shoulder-girdle, which is thereafter to be retained in proper position by a sling and a circular bandage or swathe. (See Fig. 98.)

Luxations into or behind the notch may yield to traction, or it may be necessary to use the first rib as a fulcrum over which the clavicle may be brought into place by leverage, dragging the shoulder downward. Once this luxation is reduced, recurrence is guarded against by carrying the shoulder *back* and *downward* and holding it there with a swathe, with adhesive straps, if need be; the arm is supported only by a wrist-sling. (See Fig. 99.)

Fig. 99.—Retention after reduction of backward (retrosternal) luxation. Arm held back with plaster, supported by wrist-sling, confined by a swathe.

Apparatus ordinarily used consists of a sling or strapping so applied as to take the weight of the arm and shoulder-girdle, holding the arm forward or back as may best serve in the given case to maintain the joint in its best position.

In any or all of these forms there should be fixation for at least three weeks.

* In a case recorded in the City Hospital Records of 1889 a luxation of the clavicle up and forward could be reduced and retained only by putting the hand on the opposite shoulder, and a pillow between the shoulders. The patient was kept in bed three days, then sent out with the dislocation held reduced with ordinary apparatus.

Slaughter's case above mentioned (p. 129) belongs here.

† The City Hospital Records give a case (service of the late Dr. C. D. Homans in 1886) in which a dislocation of the sternal end down and forward was successfully held by the figure-of-8 bandage, applied as it has more lately been used for ordinary clavicle fracture.

Massage is not called for, and passive motion must be restricted to the hand and elbow. Any use of the joint that will throw any strain on it whatever in less than four weeks is unwarranted.

Prognosis.—This dislocation necessarily leaves a considerable thickening, and usually a little deformity. Owing to the frequency of associated injuries, it is often somewhat difficult to estimate the result in practical disability resulting from this one lesion.

There is no great tendency to recurrence, but there is a long period of weakness and of uncertainty in the use of the arm, apt to be aggravated by abandoning fixation too early. The end-result is functionally at least fair.

With regard to the subluxations, we can be somewhat more definite, inasmuch as they are not infrequent in young athletes, particularly foot-ball players, in whom the injury to this joint is the sole result of a fall. In most cases, if not all, this apparently slight injury leaves a weakness which persists for the season, if not permanently. It is rated as a more disabling injury than the dislocation at the outer end of the clavicle occurring in these same men from like causes.

Case—Preston. Examined by courtesy of Dr. E. H. Nichols, 1907. Healthy negro of about forty, crushed under a team.

Shows caving in of the whole upper side of the right chest. The cartilages of the first, second, and third ribs are prominent. The sternal ends project, while the ribs are displaced backward. The fourth rib shows a sharp bend at the costochondral junction. There is a question whether some or all of these first four ribs have not also been fractured near the axillary line, as well as displaced. The clavicle shows at its inner end a displacement from the sternum backward, inward, and downward, but displaced not over $^3/_4$ inch. This displacement seems to have caused no symptoms at all. The outer end of the clavicle is completely torn loose from the acromion, and displaced two fingerbreadths upward. Beneath it the whole shoulder and shoulder-blade have fallen inward and forward on the sunken-in chest. With considerable force it is possible to reduce this scapular dislocation, but not to hold it in place. There seems no question that the conoid and trapezoid ligaments must be ruptured in this case. There is no disturbance of sensation or motion in the arm. There is no unnatural mobility of any of the ribs. There has been no crepitus.

This case has shown no interference with respiration, no great pain or lameness, and is now, ten days after the injury, sitting in a chair apparently perfectly comfortable. Can use the arm to some extent, but his control of it, although he has no pain, is distinctly poor.

Dislocation of the Outer End of the Clavicle

This is a common accident, and always results from one form of violence, namely, a blow on the shoulder, such as is received in a fall from a horse in which a man pitches on his shoulder, and either breaks the clavicle or, less commonly, tears its outer end loose. The opposing

force that renders this possible is, of course, the attachment of sterno-mastoid and trapezius muscles to the clavicle.*

Lesions.—The injury produced is a tearing across of the ligaments between the clavicle and the acromion on top. The extent of lesion beyond this probably varies with the case.

Apart from this tearing of the upper portion of the capsule and the protrusion of the end of the clavicle from the stripped-up sleeve of ligament and periosteum, there is usually no lesion described. From observation of cases I am convinced that while this may be the sum of the damage in most cases, there must be much more damage in some of the severer ones. Certainly in two cases that have come under my observation the coronoid and trapezoid ligaments were wholly torn loose, and the clavicle had ascended upward and into the neck, producing an

Fig. 100.—Luxation of the outer end of the clavicle upward, with great displacement. Result of a crushing accident. Operation refused. Considerable disability six months later, probably permanent.

Fig. 101.—*X*-ray of the author's case shown in Fig. 100 (retouched).

astonishing deformity which, in one case at least, showed slight increase after the man began to use the hand for work (Fig. 100).

In the cases shown in Figs. 102-105, on the other hand, I think it is very doubtful if any lesion existed beyond simple tearing of the acromio-clavicular ligaments. Such separation as here occurs may be, in part, allowed by the slack of the coracoid ligaments, and may be, in part, due to a slight rotation of the scapula around the coracoid process as an axis. (See Fig. 106.) Certainly in these cases the clavicle is not freely movable, and there is no tenderness at any time in the region of the coracoid process.

There are, then, really two classes of lesion included under this dis-

* This is a common foot-ball injury. See Nichols and Smith, Boston Med. and Surg. Jour., cliv, 1906, p. 1; Nichols and Richardson, *ibid.*, clx, 1909, p. 33.

location—serious, according as the damage is confined to the region of the joint itself or involves damage to other attachments of clavicle and scapula.

Diagnosis.—Ordinarily, the diagnosis is obvious; the shoulder, as

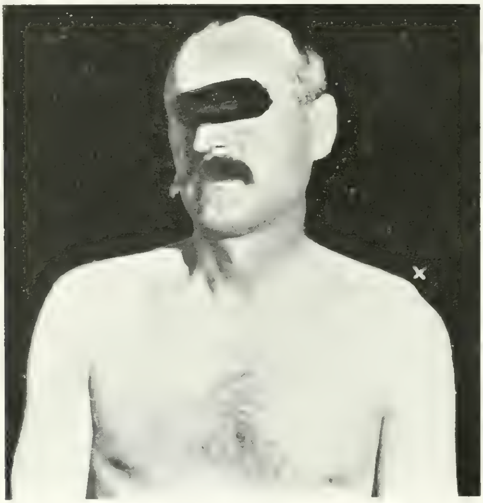


Fig. 102.—Luxation of outer end of left clavicle (author's case).

the patient stands up, drops below its normal level, and the outer end of the clavicle, held by the neck muscles, rises above the acromion for an appreciable distance. The muscles, and especially the trapezius, are

Fig. 103.—Luxation of outer end of left clavicle upward (author's case).

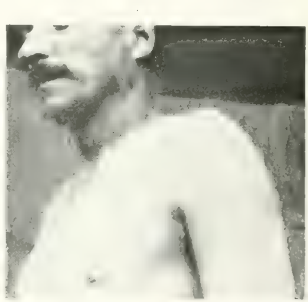


Fig. 104.—Lateral view of same case as Fig. 103.

held tense in spasm. On examination it is easily seen that the acromion lies distinctly below the outer end of the clavicle. (The two shoulders must be compared, because many individuals have a high spur on the

outer end of the clavicle, which gives *normally* an apparent difference n level at the joint.) (Cf. Fig. 136.)

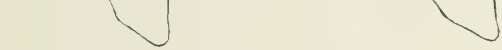
As a rule, there is comparatively little pain or tenderness, and the swelling is inconsiderable. On lifting the arm upward with a hand

Fig. 105.—View of dislocation of outer end of right clavicle upward, seen from above (author's case). The spur seen is the outer end of the clavicle.

under the elbow the deformity decreases, and in many instances disappears (Fig. 107), *only to reappear when the arm is dropped.*

The condition can hardly be confused with anything save a fracture of the clavicle near its outer end.

Treatment.—There is, in the simple cases, no difficulty in reducing the dislocation, and ordi-



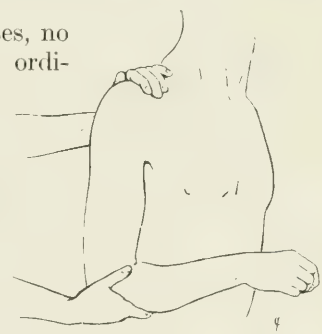


Fig. 106.—Shows how, by rotation of the scapula (produced by the weight of the arm), a separation between acromion and clavicle occurs without tearing of trapezoid or conoid ligaments.

Fig. 107.—Shows the method of reduction (and diagnosis). Press down on the clavicle with one hand, and lift the elbow with the other.

narily there is nothing to show the alleged entanglement of the torn capsule. Not uncommonly, however, the reduction happens without any click or sensation of contact of hard surfaces, and there is some question of the completeness of reduction. Here, as in the rare cases of any actual difficulty in reduction, it would seem to be a question of

interposition of capsule fibers between the joint surfaces. In such cases, owing to the other ligamentous connections of the parts, manipulation seems to be of no avail, and we must be satisfied with a partial, not a perfect, reduction, unless we wish to operate by incision.

In the cases of severer type with *torn coronoid and trapezoid ligaments*, the displacement is exaggerated, and not only is the shoulder dropped, but the clavicle is actually dragged up into the neck. (See Figs. 100 and 101.) Here there would be no difficulty in reduction if the shoulder could be lifted high enough, but it cannot be so lifted and satisfactorily held, nor can the clavicle be held down, and in this class of cases operative measures alone seem to promise any chance of even reasonably good results.

In the simpler cases, where an apparently complete reduction is

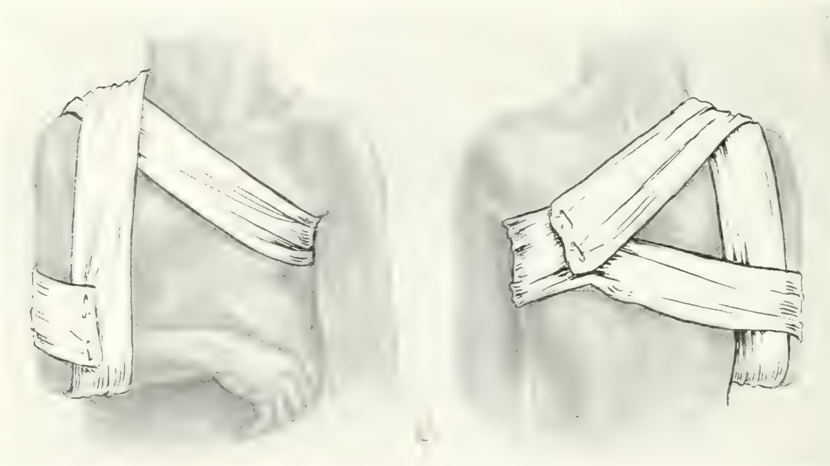


Fig. 108.—Dressing for acromioclavicular dislocation.

easy, the problem of treatment is simply to sustain the weight of the arm and to make enough pressure on the outer end of the clavicle to counteract the spasm of the trapezius. Simple as this is in statement, it is almost impossible to accomplish exactly.

I have never succeeded in getting a perfect result.

The trouble is essentially in the impossibility of sustaining the weight of the arm for many days without making unbearable pressure on the bent elbow. The apparatus which best approximates the result seems to be one shown in Fig. 108, devised for the treatment both of this condition and of clavicle fracture. Its application is obvious from the figures appended.* Stout muslin, folded, is the material used.

*This excellent and simple bandage was originated (about 1905) at the Relief Station of the Boston City Hospital. I cannot discover who invented it, but can recommend it highly, from experience with it.

The only other apparatus from which I have had any decent results is Stimson's "figure-of-8" of adhesive plaster, running under the elbow, crossing above the clavicle on the same side, and carried in both front and back toward the opposite axilla. (See Fig. 109.) The "Sayre bandage," despite all care, makes too great pressure on the elbow. It is efficient, but rarely tolerated by the patient. (See Fig. 118.)

Whatever apparatus is used should be retained at least three weeks. Any work involving strain must be avoided for at least six weeks.

Operative Treatment.—Operation has often been proposed, and occasionally carried out, even in the less severe cases. The infrequency with which it is performed is due to the fact that patients consider the injury trivial, because it is not very painful. There is no question that the operation is indicated in cases in which the coracoid ligaments are evidently torn. In the milder cases it will probably be wise to operate in all cases, even of milder grade, in which the shoulder is likely to be called on for heavy work. My attitude in this regard is based on the better results, the trifling operative risk, and particularly on the *more rapid* return to working strength.

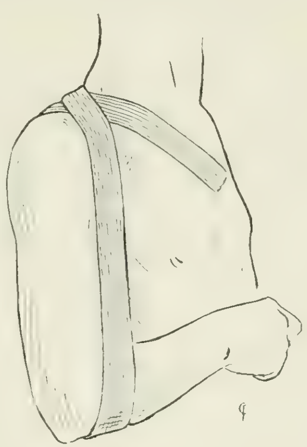


Fig. 109.—Stimson's adhesive dressing.

I would not, however, be understood as failing to recognize the fact that excellent functional results, even if with deformity, *may* follow the conservative method of treatment.

Operative treatment consists of an incision over the joint, an exposure of the joint surfaces, including a proper removal, or lifting out, of such shreds of capsule, etc., as overlie the articular surface of the clavicle. Cross-cutting of the capsule may be necessary. Then the luxation is reduced, the bone-ends are drilled and fastened together with either silver wire or kangaroo tendon.* Then the capsule is sewed up with a stitch or two, and the skin sutured. A sling to take the weight of the arm is needed for two or three weeks. At three weeks things are solid enough to allow light use.

Results.—It is the current belief that this injury does not cause disability. To this I cannot subscribe. It is true that in the majority of cases no such disability results as to keep a man away from his work after a few weeks, but in a good many cases, where the work is heavy,

*With a view to preserving mobility in the joint, a scheme has been devised of carrying the suture in a figure-of-8 crossing in the joint. It is ingenious, but in view of the good result of the ordinary operation, is probably superfluous. I have found the simple suture perfectly satisfactory. (Hopkins, Ann. Surg., 1902, xxxv, 650.)

there is complaint of some weakness in the arm, especially on lifting with the hand, and this weakness does not seem to improve with time. There remains a certain laxity of the joint, though with a displacement of not over 1/2 inch. For ordinary use the joint is perfectly serviceable. Under the pressure of heavy lifting or strain the separation tends to increase gradually for some months, and there is apt to be decided loss of lifting strength with some tenderness.

In case the coracoid ligaments are torn, the separation is great at the start and remains great, and the deformity is very considerable, as is also the loss of working power. In two such cases observed months after injury there was also marked limitation of motion. To some extent passive motion was limited, but more particularly there was inability to raise the arm much above the horizontal, due to loss of all effective muscle attachments. In one of these cases the disability for many months after the injury was such as to prevent any but very light work, and the patient stated that he was unable to do even light work with any handiness or comfort.

The results obtained by operation are distinctly good. Practically, a normal shoulder results, with all the motion necessary to this joint.* Even where wire is used, it does not give rise to any trouble. There is no danger save the slight one of sepsis.†

FRACTURE OF CLAVICLE, OUTER END

Fracture of the outer part of the clavicle *internal* to the ligaments differs in no essential from a break at the usual point. (See Figs. 110 and 111.) When we come to breaks in the outer end *among* the ligaments, the matter is very different. (See Fig. 112.) There can no longer be any free displacement of the inner fragment upward; the fractured ends necessarily remain pretty nearly in contact, and the deformity must be confined to a bending—a "hinge" displacement.

As a rule, the fracture results from a fall or from a blow striking the outer end of the bone from above. Consequently, the displacement tends to be of the outer fragment downward. If there is no original displacement, the weight of the arm alone tends to displace it in this way. In one case alone have I seen the reverse direction of displacement before reduction.‡ It is doubtful if actual impaction is ever present, but often there is no mobility or crepitus elicited by any reasonable handling.

*The normal range is very slight—the clavicle is very movable, but the scapula moves with it always.

†I have had the chance to keep track of one case operated on by a man not a surgeon, in which there was a lively sepsis, but even here the end-result was not ankylosis, but a good joint with sufficient movement.

‡See Fig. 114. This fracture resulted from a fall in which the blow was received —as shown by contusion and abrasion—at a point internal to the fracture.

The displacement is limited—it involves, even for slight displacement, a considerable rotation of the scapula, which is limited by the strong muscles that hold the bone in place. (Compare Fig. 106.)

As a result of direct violence, or as a complication of the acromioclavicular luxation, there may be a break or chipping into or close to the joint. Here the displacement either is that of the luxation, or it will closely resemble such luxation, distinguishable from it only by slight difference in position of the deformity and by the presence of crepitus on reduction.

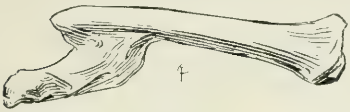


Fig. 110.

Fig. 111.

Figs. 110, 111.—Sketched after Malgaigne's plates. Fractures at the outer end, but *inside* the ligaments.

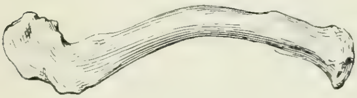
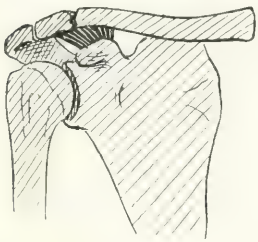


Fig. 112.—Fracture at the outer end of clavicle among the ligaments. Left clavicle from above (Warren Museum, specimen 7900).

Fig. 113. Fracture of outer end of clavicle (after reduction).

Fig. 114.—Fracture of outer end of clavicle unreduced, showing the reverse of the usual original displacement.

Diagnosis.—Diagnosis depends on local tenderness, on bone thickening, on swelling, with some, though not much, deformity at a point $\frac{3}{4}$ to 1 inch internal to the joint, and on the crepitus sometimes obtainable by rotating the scapula (by lifting the arm, etc.; see Fig. 115), or by shoving the arm up.



Ordinarily, the local tenderness and ecchymosis are the basis of diagnosis.

Treatment.—Reduction is by manipulation and by shoving the arm upward, or by leverage. (See Fig. 116.)

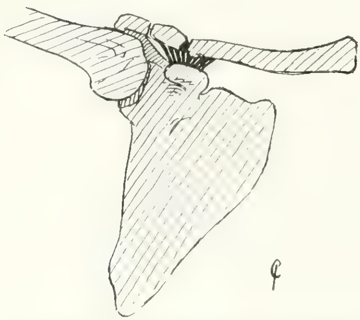


Fig. 115.—Abduction test to obtain crepitus in fractures of the outer end of the clavicle. Only in this way can we get motion between fragments in this region.

Fig. 116.—Reduction by leverage: the elbow is shoved inward; the operator's arm in the axilla is the fulcrum over which the shoulder is pried outward and upward.

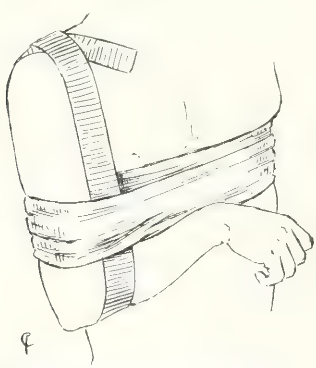


Fig. 117.—Adhesive to hold fragments, and circulars to steady the arm.

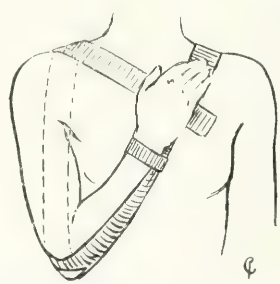


Fig. 118.—Sayre's clavicle dressing of adhesive plaster, often useful in these fractures at the outer end.

After-treatment is as for ordinary acromioclavicular dislocation, or by support in the ordinary apparatus for fracture of the shaft of the clavicle, but retention in apparatus is easier than with luxation. Often

simple firm strapping with adhesive plaster to steady the fragments and a firm sling will be enough. (See Fig. 120.) Retention in apparatus is not necessary after two or three weeks. Use of the arm will, of course, be postponed a little longer.

(In the exceptional case above noted, with *upward* displacement, the

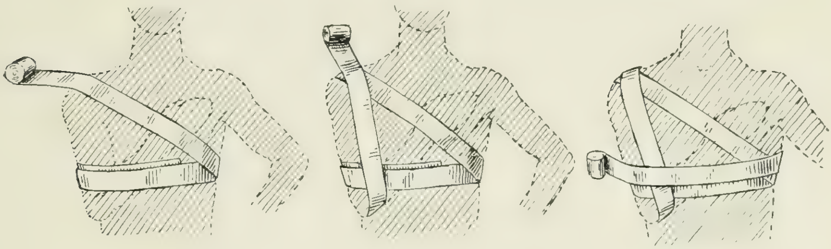


Fig. 119.—Shows the application of the Velpeau bandage, largely used in all clavicle injuries, but really of little use save as a neat covering for the adhesive strips that do the work.

most comfortable and apparently efficient treatment was to drag the arm downward and supplement the weight of the arm by tight strapping over a pad on the *top* of the shoulder at the outer end. The result was functionally perfect, without visible deformity.)

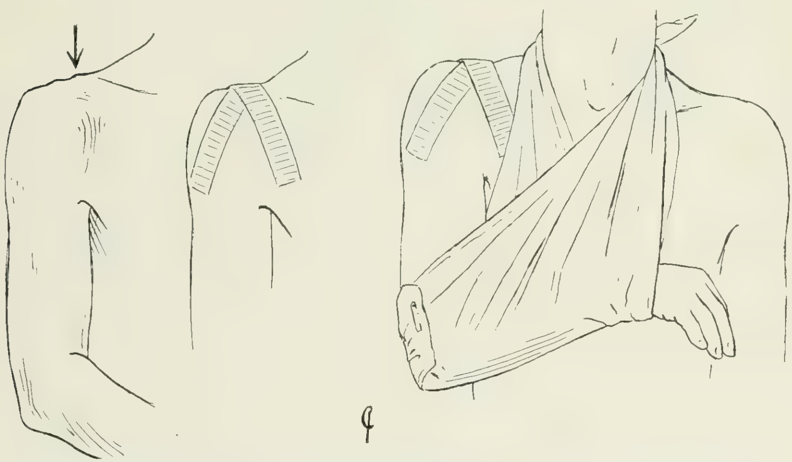


Fig. 120.—Adhesive plaster to steady the fragments, and a strong sling, applied so as to *lift and hold* the entire weight of the arm. This makes a very efficient dressing in most cases if properly applied.

Results.—The results are good, even if deformity is not reduced perfectly. There is apt to be a good deal of stiffness for a time, but in ordinary normal patients this entirely wears off and free motion and strength return.

SEPARATION OF THE EPIPHYSES OF THE CLAVICLE

The epiphysis of the inner end (a mere plate of cartilage) begins to ossify at about eighteen years, and unites at from twenty-two to twenty-five. Poland cites seven cases of its alleged separation, some of them distinctly doubtful. The lesion is to be handled like a fracture of the inner end.

At the outer end there is no point of ossification, but there is in children a cartilaginous end that may be torn loose.

I have met with but one case, the result of quick delivery by podalic version in a case of eclampsia. The case when I first saw it, at two weeks, presented a condition curiously similar to that of the *complete*

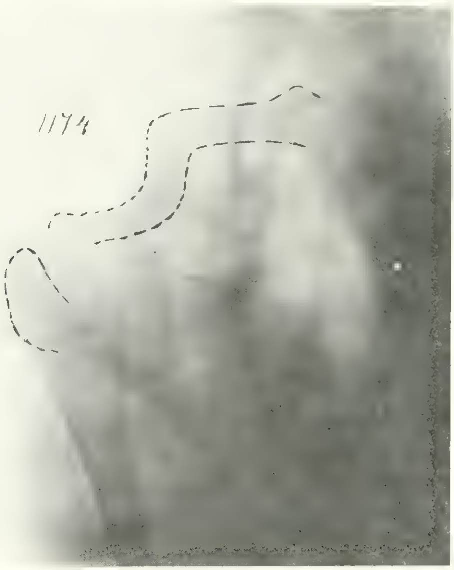


Fig. 121.—Old fracture of clavicle taken at an angle. Was a question of non-union. Small girl, aged ten. Illustrates the great distortion almost unavoidable in x-rays of the clavicle. Clinically, the position was not bad.

dislocations (see Figs. 100, 101), with the proximal end drawn high up into the neck, almost parallel to the tense sternomastoid muscle. Only the square, blunt end and the site of injury spoke for epiphyseal separation rather than fracture.

Massage and persistent traction by an efficient nurse brought the fragment near where it belonged—to a point where pads and strapping could be borne without a slough, and union took place with little deformity. After six months there was no deformity.

CHAPTER XI

THE SCAPULA

LUXATION BACKWARD

Dislocation of the scapula must obviously be a change of relation between shoulder-blade and chest, with or without damage to the chest, for dislocations between scapula and clavicle are classified as dislocations of the clavicle. There are no ligamentous connections between chest and scapula; therefore any scapular luxation must be from a caving-in of the chest or from a change in relation between scapula and muscles. Such a condition as the latter is not ordinarily recognized, but I believe it to exist.* I have seen no case recognized as such, but have had the opportunity of reading over the detailed case-records of a curious series of cases that fell into the hands of a friend of mine.† The diagnosis seems justified by the results obtained in his cases.

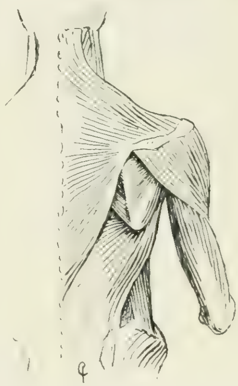


Fig. 122.—Luxation of the scapula. The latissimus dorsi lies *under* the angle of the scapula (schematic).

The lesion seems to be a slipping of the edge of the latissimus dorsi inward under the angle of the scapula, between it and the thorax. (See Fig. 122.)

It occurs, it would appear, from extreme upward traction of the arm during muscular effort. In one of the cases a man tried to save himself from a fall by grabbing at a plank as he fell; in another the attempt was to hold a rearing horse as he rose; the third was a sparring accident. All the cases were first seen after a week or more, during which time there had been no tendency to improvement.

All were characterized by inability to lift or abduct the arm beyond a very slight range. In all there was prominence of the scapular angle below, as in the case of "angel-wing" paralysis.

In this series extreme backward position of the shoulders, maintained by a figure-of-8 bandage, very quickly led to permanent cure, apparently by self-reduction of the deformity through slipping of the muscle (held

* The relations of the condition to be described to the apparently unexplainable traumatic "paralyses of the serratus magnus" (accepted by neurologists) is suggestive. I have not yet been able to investigate the matter.

† Dr. David McIntire, of Dorchester, Mass.

relaxed) into its proper place. In all these cases recovery was prompt and complete.

INWARD LUXATION

The only class of luxation cases besides that just noted is that of "inward" luxation, cases in which the scapula is displaced inward into a gap produced by rib fracture. I have seen two such cases only, and have not chanced on any literature that contributes to knowledge of lesions or treatment.

In these cases there was an extensive rib smashing—a fracture of several ribs. In one case posterior luxation of the ribs at the costochondral joints was combined with fractures of the same ribs near the "angle" of the ribs behind: the scapula was less prominent than normal at the side and back. That was all. The patient recovered without symptoms referable to this lesion.

The second case showed a scapula apparently driven into the chest through a space furnished by the caving-in of ribs between anterior and posterior fractures. There were no symptoms characterizing this injury. The patient died from alcoholism plus trauma, and neither skiagraph nor autopsy was obtained.

Save for support of the arm, after outward traction on the whole shoulder-girdle I see nothing that can be done in these cases.

Fig. 123.—Congenital luxation of scapula on the right.

CONGENITAL LUXATION OF SCAPULA

There is a congenital "luxation" of the scapula (Hochstand der Scapula of the Germans), but it is not likely to be confused with any traumatic condition. The position of the scapula, its articulation with the (usually present) superfluous rib, etc., may be understood from Fig. 123. Marked improvement in position and mobility is secured by operation on these cases.

FRACTURE OF THE "SURGICAL NECK" OF THE SCAPULA

This form is described in the older books with particularity;* in modern literature I have not met it, nor do I know anything of it clinically. It is supposed to be characterized clinically by the usual pain and disability of injuries in this region, but especially by the presence of a downward dropping of the whole arm (plus the glenoid fragment),

* Astley Cooper says, however (after he had dissected two cases in which he had made this diagnosis that proved to be fractures of the anatomic neck of the humerus), "I must confess that I now doubt the very frequent occurrence of fracture of the cervix scapulæ." ("Lectures," third American ed., p. 236.) As he originated the usually accepted description, I think we may accept this as a retraction.

reducible with crepitus by upward pressure at the elbow, but reproducing itself on withdrawal of such upward pressure.

There would seem a chance of confusion with acromioclavicular luxation, or with the downward drop seen in old deltoid paralyses after reduction of luxations, but neither of these should give crepitus, save the soft crepitus of secondary arthritis.

The *x*-ray should be decisive in case of doubt.*

Poland reports a unique case, due to crushing, of separation of the whole *epiphysis* in a child. The epiphysis of the articular head includes more than the glenoid neck, but, according to most authori-

Fig. 124.—Fracture of the "surgical neck" of the scapula: *i. e.*, separation of glenoid and coracoid portions from the body.

ties, not so much as Poland figures. His data are from an autopsy specimen, however, and no doubt in this case coracoid and acromial base did belong to the epiphysis, contrary to the rule. (See Fig. 125.)

Treatment.—The problem is nearly that met with in acromioclavicular dislocations; we must support the whole arm and get counter-pressure from above on the clavicle. The apparatus used in the clavicle luxation is obviously that indicated here.

* Since writing this, the *x*-ray reproduced in Fig. 124 was discovered. I had no opportunity to examine the case. The diagnosis was made by the *x*-ray.

FRACTURE OF THE CORACOID PROCESS

The existence of this fracture is amply attested, but, save as it occurs as a complication of luxation (where it is unimportant), we know almost nothing about it.

Personally I know of only one uncomplicated case, well shown by an excellent x-ray, now lost, in which no definite signs could be elicited even directly after the injury; the local sensitiveness was gone within a week, and soon after this the slight disability began to wear off.

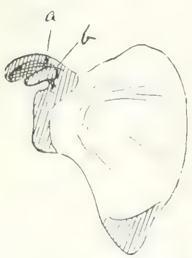


Fig. 125.—Separation of the scapular epiphysis as a whole (sketch from Poland's figure). *a*, Acromion; *b*, coracoid epiphysis.

Fig. 126.—Epiphyses of the coracoid, complex, but not important. (Sketched from Poland's Fig. 24 after Rambaud and Renault).

For **diagnosis,** apart from the x-ray we have only localized tenderness, ecchymosis, and the possible palpation of a movable fragment to go on. Theoretically, we should get pain on resisted flexion at the elbow and on active supination, owing to the fact of the origin of the short head of the biceps from this process.

The **treatment** is obviously one of simple fixation of shoulder and arm with the elbow at a right angle. Union seems to be by bone, at least as a rule. No permanent ill results are on record.

FRACTURE OF THE GLENOID CAVITY

This is rare, except as an incident of shoulder luxation. The anterior edge is that most often chipped off. Such chipping is reputed a common reason for recurrence of anterior dislocations, and has been invoked as cause in the permanent luxations roughly classed as congenital.*

Save for the ready reluxation of the reduced head and occasional crepitus, we have no signs for diagnosis. Without luxation the only case of my own I was ever sure of was discovered by accident during an arthrotomy. I know only one other, discovered unexpectedly by the x-ray. The treatment is fixation, of course, with support of the arm.

The results, save for the possible tendency to recurrence of dislocation, seem to be perfectly good, and such recurrence, due to this lesion, seems rare, at worst.

*It may here be *part* cause, but some such cases are obviously due to primary defects of development, others to obstetric paralyses, etc.

FRACTURE OF THE ACROMION

Fracture of the acromion is often diagnosed, but the accident is, in fact, rather rare. The cause seems to be direct violence always, except where the fracture complicates luxation. The disability is not complete, but nearly so.

The diagnosis rests on external marks and on localized tenderness, hence there is great chance of error. Rarely we may find crepitus, mobility, or obvious deformity.

Any deformity is in the direction of a dropping downward of the acromion. It apparently is rarely more than slight.

The question has often been raised as to whether apparent injuries in this region, shown by mobility or by the x-ray, may not rest on separate ossification-centers rather than on trauma as the ultimate cause. There is, in fact, an epiphysis here, and it unites late.* (See Figs. 127 and 128.)

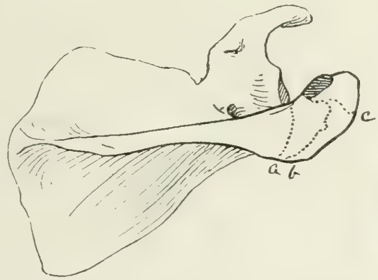


Fig. 127.—Epiphysis of the acromion. The dotted lines show the varying site of the epiphyseal line. The dark shaded area is the joint surface with which the clavicle articulates.

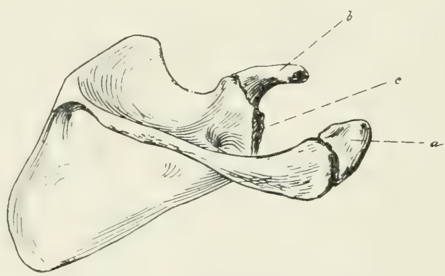


Fig. 128.—Right scapula from above and behind: *a*, Epiphysis of acromion; *b*, epiphysis of coracoid process; *c*, epiphysis of glenoid cavity (from specimen in the Warren Museum).

All we can say is that the ordinary signs of trauma ordinarily mean trauma; if the x-ray shows apparent separation without these signs, it is of no consequence; if sharply localized soreness, ecchymosis, pain on motion, and crepitus are present, with apparent separation or loosening of the acromion, it is of very little consequence whether this separation be a fracture or a traumatic separation of an epiphysis.

In a series of cases diagnosed by house-surgeons and others as acromial fracture, I am bound to say I have found various other injuries, but never signs of either fracture or separation of the acromion. Most of them were clavicle fracture or acromioclavicular dislocation.

Perhaps it is fair to say that soreness over the acromion following trauma proves nothing as to bone damage, unless supported by other signs of such damage, and that luxation and fracture of the outer end

* Poland, Traum. Seps. of Epiphyses, p. 153, gives a cut of specimens showing such (permanent?) separations.

of the clavicle both give similar pictures and are both far commoner than the acromial injury.

Treatment.—In case we have either acromial fracture or epiphyseal separation, the indications for treatment are the same, viz., immobilization and support of the elbow to relieve traction through the muscles, and consequent displacement due to the weight of the arm. In other words, we have here a problem of support and fixation exactly equivalent to that in acromioclavicular luxation. We are to use the same reduction and the same apparatus, applied for about the same length of time.

Results.—I have so far not learned of any case of acromial fracture, or alleged acromial fracture, in which any permanent disability has resulted. It is alleged that the acromial fractures may unite by fibrous tissue only. Probably fibrous union in this region, given a close approximation, would be about as serviceable as union by bone.

FRACTURE OF THE SPINE OF THE SCAPULA

This is not a very rare accident. It may be merely a smashing of the edge, or may rarely run through, so as to separate the whole base from which the acromion springs. It occurs, usually, if not always, as a result of direct violence.

Diagnosis presents difficulty only because of the usual presence of much swelling.

The diagnosis depends on an interruption of the easily palpable line of the scapular spine, with occasionally a palpable mobility, on local tenderness and thickening, on crepitus, and on reflex spasm of the shoulder muscles.

Treatment.—The treatment is one of fixation only. The deformity is slight; the healing is by bone callus, and the chance of later trouble is slight.

Apparatus to be applied is only the usual firm sling and circular, for support of the weight of the arm and for immobilization.

Results.—Save for one case of delayed, but eventually solid, union, I have seen no serious damage from this fracture. The local deformity which may remain is of no consequence and there is no permanent disability.

FRACTURE OF THE BODY OF THE SCAPULA

This lesion results always from a direct blow—usually from a heavy fall on the back. It is less rare than would be supposed from the account given in text-books. In a limited experience I have met with at least 10 cases, more than my cases of any other scapular fracture.

The lesion is a break, more or less accurately transverse, across the

scapular body below the spine. There may be some comminution of fragments. In one case observed there was a green-stick fracture convex forward, with the lower end of the scapula sharply projecting.*

Diagnosis.—The diagnosis is not always easy, for there is, as a rule, much hematoma, more or less limited by fasciæ, and, therefore, tense and hard. Every case of marked hematoma and tenderness limited to the region of the shoulder-blade is suspicious. The disability of the arm is nearly, if not quite, complete. Lifting or sharp abduction of the arm gives sharp pain. It is sometimes possible to feel the break in the line of the *vertebral* edge of the shoulder-blade, and, by grasping the

Fig. 129.—Multiple fractures of scapula. Railroad accident. Man, forty-three years of age. Lived one day (Warren Museum, specimen 6028).

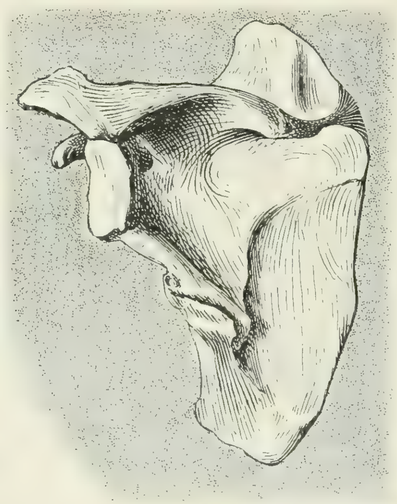


Fig. 130.—Fracture of the body of the scapula. Bony union with moderate displacement (Warren Museum, specimen 8111).

bone as shown in Fig. 131, it is usually possible to appreciate the presence of some lateral mobility, and sometimes crepitus is obtainable.

There is shortening of the bone measured from the spine (point x Fig. 135, is usually palpable) to the angle, but, owing to swelling, this measurement is hard to get accurately.

Treatment.—It would be desirable to prevent the overlapping of the fragments or reduce its extent, but I know of no way. Fortunately, the overlap is very slight. The actual treatment used is to strap the

* In a boy of about ten years; he fell out of an apple tree on his back. In reducing the displacement the fracture was rendered complete. Recovery under usual treatment was, as is usual, complete and uneventful.

scapula down with adhesive plaster with the shoulder carried *back* to relax all muscles, and then to support the arm in a sling and confine it

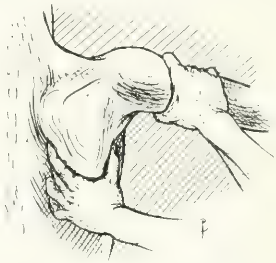


Fig. 131.—Manipulation to test fracture of the *body* of the scapula. By shoving or pulling the upper and lower parts in opposite directions mobility and (sometimes) crepitus are observed.

with a swathe. Absolute immobilization will not be needed for more than three weeks, as callus-formation is prompt.

In all the cases I know of * the end-result has been excellent—practically perfect, despite slight persistent shortening and overlap.†

* Save in one case, where there was a medicolegal interest, with obviously fraudulent claims of pains here and elsewhere.

† The bone is here thin, and the overlap, therefore, interferes little with the conformation of the scapula to the chest, over which it slides.

CHAPTER XII

THE SHOULDER

LANDMARKS

The landmarks of the shoulder are five:

1. The acromion.
2. The spur of the clavicle.
3. The coracoid process.
4. The most prominent part of the spine of the scapula, the spur of the acromion.
5. The head of the humerus.

The **acromion** as a landmark is obvious in the most muscular or

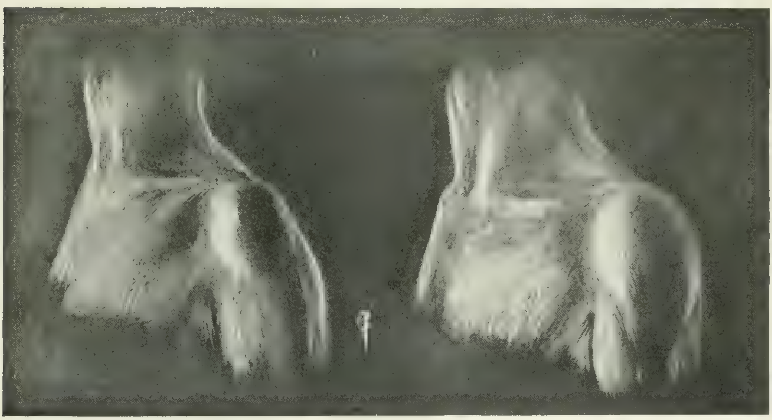


Fig. 132.—Shows, on the left, the female, on the right, the male shoulder contours. There is a characteristic and reasonably constant difference.

even in the fattest shoulder. Its relative prominence is dependent on its relation to the tuberosities of the humerus. Even in case there is much swelling or much deltoid wasting, there is little difficulty in palpating—and accurately—the relation of these two prominences.

If the tuberosities are not in place on this test, we must discriminate as to the direction of displacement. Displacement forward and inward means either luxation at the joint or fracture near the head. Great displacement means luxation, with or without fracture.

If, as rarely happens in thin subjects, we can palpate the glenoid cavity or its edge, there is no doubt as to the presence of luxation.

Fig. 133. Cross section showing the obliquity of the scapula in relation to the trunk. The glenoid cavity faces as much forward as outward.

Clavicle Spur.—The spur that exists on the clavicle in a certain proportion of persons is sometimes a valuable confirmatory landmark when there is any trouble finding the acromion or the scapular spine.

Its situation is evident enough from Fig. 136.

The **coracoid process** is definitely palpable in the normal individual by the method shown in Fig. 134.

If it cannot be felt in this way, the chances are there is serious disturbance of relations, though much fat or much swelling may rarely interfere. In dislocation *forward* it is usually impossible to feel the coracoid. If the humeral head lies so close that the coracoid cannot be felt as a separate prominence, the presence of dislocation is almost certain. *Fractures* of the coracoid are vastly rare, and even when they occur, appreciable displacement of the coracoid is improbable.

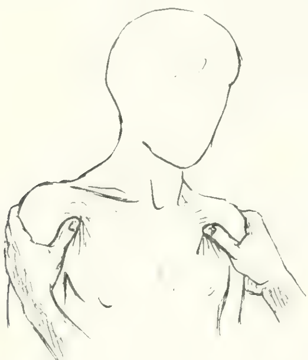


Fig. 134.—Palpation of coracoid processes.

Fig. 135.—Scapula from above. Shows the spur of the acromion or of the spine at ×.

The **spur of the acromion** lies behind the prominent external portion. It is an angle rather than a process; its relation to the bone is shown in Fig. 135; its external relations, in Fig. 137. It is constant, though varying, as do other such spurs, in its prominence. Being subcutaneous, it is readily found.

Fig. 136.—× shows the projecting spur of the clavicle next the gap representing the joint with the acromion and the scapular spine.

The **head of the humerus** is readily palpable as a rounded mass. (See Fig. 138.) Usually the contrast between the prominence of

Fig. 137.—1, End of clavicle; 2, acromion process; 3, "spur" of acromion.

Fig. 138. Palpation of the head of the humerus from behind; the thumb lies on the acromion process.

the greater tuberosity and the groove for the biceps may be made palpable by rotating the arm.

Shoulder Luxation

This is the commonest of the major luxations—perhaps the commonest of all luxations. It is rare in the first two decades of life; very rare in small children. Much ingenuity has been spent (wasted, perhaps we may say) in the minute subdivision of possible types of shoulder luxation. Not less than 15* types have been named, with much confusion of definition. It is for us to consider what types are clinically distinguishable, and, further, to consider how far this discrimination of types may affect intelligent treatment or prognosis.

Considered from this extremely practical point of view we have: Anterior luxations; luxations downward; luxations backward; with the vastly infrequent cases of luxation up and forward, of luxations far downward (luxatio erecta), of luxations in which the humerus is driven

*Subcoracoid, intracoracoid, subclavicular, supracoracoid, subglenoid, axillary, supraglenoid, luxatio erecta, retroglenoid superior and inferior, subacromial, retroaxillary, subspinous, intrathoracic, subtricipital. These are all descriptive names that have been used, several of them synonymous, several as to which no man may say exactly what they mean.

through the chest-wall, and of the luxations complicated with, or perhaps possible only in connection with, fractures of various sorts.*

Fig. 139.—*Old* subcoracoid luxation. Shows the new flat socket and the eroded head (Warren Museum, specimen 5173).

Fig. 140.—New joint at right angle to the glenoid and just in front of it (after a plate by Malgaigne). Old subcoracoid luxation, unreduced.

Fig. 141.—Old subclavicular luxation. Shows the big loose new capsule communicating with the old (Warren Museum, specimen 1172).

FORWARD LUXATIONS

These include the subcoracoid and those forms variously called intracoracoid or subclavicular. Far and away the most common type is that called subcoracoid, and this will be described as the *typical* lesion. It consists of a displacement of the head of the humerus forward and inward, to a point below and just external to the coracoid process, from which process it is separated by the subscapularis muscle or its remnants.

Etiology.—Subcoracoid dislocation results, so far as we may deter-

* For example, upward luxation with acromial fracture.

mine, from forced abduction, from a blow on the rear and outer side of the shoulder, or from forced inward rotation. Muscular contraction undoubtedly plays a part, and may perhaps be the sole cause of dislocation.

The academic theory has been that forced abduction, with leverage across the acromion as fulcrum, is the common cause. This I take the liberty to doubt, first, because the acromial region rarely shows even local tenderness; second, because all *abduction* subcoracoid luxations seem to occur under conditions of strong muscular contraction; tense adductor muscles seem much more likely than the bone to be the usual fulcrum. With forced abduction we *may* have three points that may act as the fulcrum: (*a*) the acromion; (*b*) the coracohumeral ligament; (*c*) the tendons of the contracted pectoralis major and the latissimus dorsi.

It would be folly to try to determine this matter exactly.

It is perhaps fair to say that my experience of clinical histories as given leads me to infer that the fulcrum point furnished by the *adductor muscles* has not been given fair weight.*

So, too, in the luxations occurring from sudden forcible *inward* rotation, inflicted, for instance, in foot-ball or in sparring, there can hardly be any other than a *muscular* fulcrum.

Whatever view we take of the detailed mechanism, we find, in fact, that the case histories show the cause to be either forced abduction or a blow on the shoulder, occurring with about equal frequency; luxation by inward rotation, while it does occur, is rather rare.

Lesions.—There have been a good many autopsies, and the joint lesions found are constant in the main. The rent in the capsule lies constantly on the anterior inner and lower aspect of the joint, between the tendon of the subscapularis and that of the triceps. As a rule, it seems to be a rather large tear. The capsule is torn from the humerus, or near the insertion on the humerus, as a rule, though tearing at the glenoid edge, chipping of the cartilage on this edge, or stripping up of cartilage and of the adherent periosteum near this point have been found. The *capsule*, strictly speaking, may not be torn at all in these cases.

The tendon of the subscapularis may be partly torn with the capsule, or the muscle-fibers may be torn in the later upward displacement of the head caused by the falling of the arm.

Rupture of other muscles is rather rare, but there may be tearing, more or less extensive, of supraspinatus, infraspinatus, teres minor, and, very rarely, of the teres major.

* For instance, one of my cases was that of a young, muscular fellow who jumped on a moving street-car, as he had done habitually. He had, however, underestimated the speed of the car, and threw his shoulder out, though he did not fall. There was abduction, but an abduction certainly not extreme enough to act by leverage over the acromion; we *must* assume a muscular fulcrum.

Tearing of the coracohumeral ligaments is very rare, hardly occurring save in subclavicular luxation.

It is T. Kocher's service to have pointed out that this ligament is not torn in any ordinary dislocation; that it usually determines the faulty position and the fixation of the limb; that it is the key to proper reduction manœuvers in most cases, and that its relation to shoulder luxations is something akin to that of the Y-ligament to hip dislocations.* This ligament rises from the base of the coracoid process in two diverging bands, one, the weaker, running to the greater tuberosity; the other, the important one, running to the lesser tuberosity, there to be inserted with the capsule.

In the ordinary subcoracoid form of luxation this ligament is stretched taut, and it determines both the close contact of the head with the anterior scapular surface and the fixation of the humerus in abduction.

The ordinary position of the head on the scapula is well indicated by the position of the false socket in old cases (see Figs. 139 and 140); this is confirmed by dissections of recent cases.

The head in this form of dislocation lies close under the coracoid process, separated from it by the subscapularis, entire or torn on its lower edge.

The head is not far from the joint edge, and in some cases it lies *on the front edge* of the glenoid cavity. In such cases the capsule is less torn than usual; in some cases not torn at all, but merely lifted off the edge of the glenoid, carrying the periosteum with it.

The cartilaginous edge, or even the bony edge of the front of the glenoid, may be broken away. This gives little difficulty in reduction, but probably predisposes to recurrence of the dislocation.

Fractures of the coracoid or acromion are extremely rare complications of anterior luxation.

Associated with the displacement we may have tearing not only of subscapular muscle-fibers, but of other muscles, as noted above.

The long tendon of the biceps may be ruptured or it may be displaced inward.

Either tuberosity of the humerus may be torn off. The tearing off of the lesser tuberosity frees the biceps tendon from its groove and slackens the tension of the coracohumeral ligament.

All these complications may have a bearing on future function of the arm, but have none on reduction, except in case of interposition of the biceps tendon between head and socket. Probably the adaptation of the form of reduction to the detail of these lesions will be worked out

* This parallel in detail has been drawn by Kocher in a very illuminating article in Volkmann's "Sammlung klinischer Vorträge," published in 1873, No. 61, p. 667. Kocher's first article calling attention to this ligament and its rôle in reductions was three years earlier (Berlin. klin. Woch., 1870, No. 9).

later, but at present this relation is not discovered, and our forms of procedure take no accurate notice of these details.

Rarely, the axillary vessels may be torn by stretching over the humeral head. (See under Complications.)

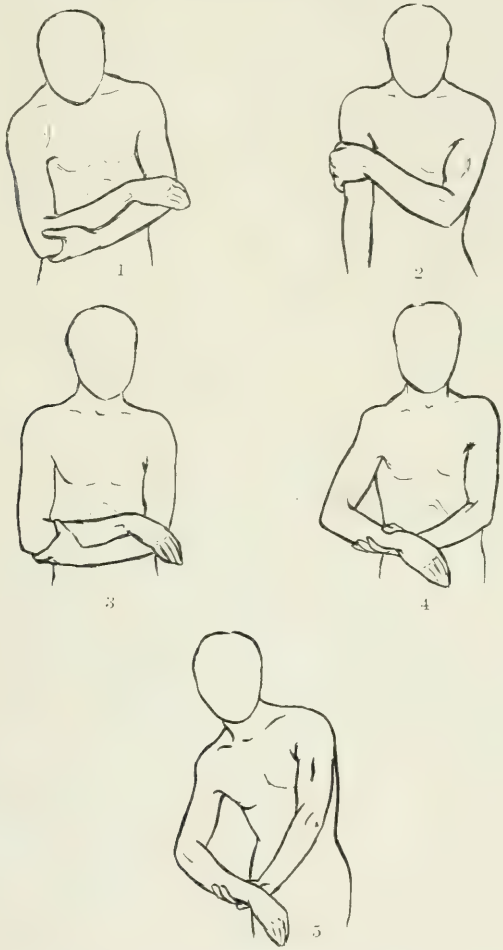


Fig. 142.—Attitudes in shoulder injuries: 1, Clavicle fracture; 2, neck of humerus; 3, humerus below the neck; 4, subcoracoid; 5, subglenoid.

Damage to the nerves by direct pressure of the displaced head, by nerve-root traction, or by the trauma of reduction is by no means unusual.

Symptoms of Subcoracoid Luxation.—The arm stands away from the side, and the elbow cannot be brought to the side. All motions are restricted and painful; the arm is practically useless.

There is a flattening of the shoulder and a hollow to be felt below the acromion.

A fulness is to be felt in front, just below the coracoid process. The head is *not* felt in the axilla.

From behind, there is a hollow below the acromion opposite the glenoid cavity (see Figs. 146, 147), but the edge of the glenoid is rarely to be felt.

The axis of the humerus, seen from the front, obviously runs too far inward—toward the clavicle (Fig. 142, 3 and 4).

Fig. 143.—Subcoracoid luxation (author's case).

The length of the arm, measured from acromion to external condyle, is *slightly increased.*

There is sharp restriction of *all* motions, limited not only by pain, but by mechanical check. Most significant is the *loss of adduction.* The *elbow cannot be brought to the side.**

In practice the diagnosis offers little difficulty to the practised eye.

First, the attitude is almost diagnostic. (See Fig. 142 and Figs. 143 to 147.)

The arm stands out from the side stiffly, and cannot be brought in.

Motion is largely lost.

*To be *absolutely* conclusive, this test should be performed with the arm in moderate outward rotation. The classic test, known as Dugas's test, is as to the patient's ability to bring the elbow to the side, with the hand on the opposite shoulder. This test occasionally fails.

The axis of the bone points wrong.

There is flattening of the shoulder.

On palpation the humeral head is gone from its normal site, and there is a mass to be felt (rotating with the shaft) close to the coracoid process.*

The inference is obvious. There can be confusion only with certain fractures of the neck or with fracture *plus* luxation.

Fig. 144.—Subcoracoid luxation (author's case).

Treatment.—Today few will dispute the preëminence of Kocher's method of reduction for most cases of subcoracoid type. This method depends on the fact that the displaced head is pressed close to the scapula under the coracohumeral ligament,—so close that it cannot rotate freely,—and that it is pulled into *inward* rotation by tension of the subscapularis.

If we rotate the arm *outward*, the head rotates over the glenoid edge; if this rotation is done slowly, the subscapular muscle is stretched and gradually ceases its resistance. During such rotation the head moves outward visibly (see Fig. 149), and *may* slip into the socket. If it does not move outward *at all* with outward rotation, this first manœuver is to be continued, or repeated, before going further.

Figs. 145, 146.—Subcoracoid luxation (author's case).

* Much has been written as to feeling "the head of the bone in the axilla." I have not yet been able to feel the head in the axilla in a *subcoracoid* case. This position of the head means a *subglenoid* luxation.

The next manœuver is to carry the arm, still rotated out, forward toward and across the body, using the arch of the ribs in a measure as a fulcrum* to lift the head of the humerus, already rotated onto the edge of the cavity, into its place.

Fig. 147. Subcoracoid luxation (author's case). This photo is interesting in that it was taken at night by the ordinary electric light of the accident room with a "Kodak."

The third step is internal rotation, with the elbow in adduction, to throw the head into its *usual* normal position.

As a rule, the head moves *outward* during outward rotation, and slips *in* with adduction. The final movement only restores the head to normal position after reduction, and clears capsular entanglements.

One point that I have found important, unpublished, I think, is the *slow* execution of the outward rotation. This wears out the resistance of the subscapularis and renders reduction easier and more certain. I am accustomed to devote from two to five minutes to this part of the manœuver, and have convinced myself that it is time well spent.

Kocher's reduction certainly is the best single routine. It is to be tried first, unless we wish to try direct backward pressure on the head, exerted by the thumbs, with the arm held in moderate abduction. The last manœuver will suffice for some cases, but for many it does not; where it works it is, of course, the gentlest method.

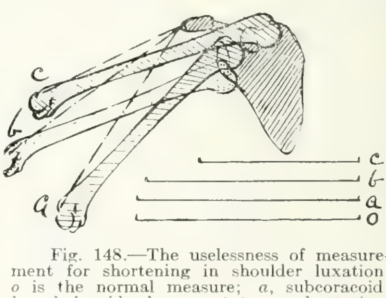


Fig. 148.—The uselessness of measurement for shortening in shoulder luxation: *o* is the normal measure; *a*, subcoracoid; *b*, subglenoid, show next to no shortening. Only the subclavicular type, *c*, is short.

Kocher's method is not violent, not very painful, and may, in the rule, be carried through without anesthesia. Properly done, with a real understanding of what happens at one end of the bone while we work at the other, it almost invariably succeeds; I have not chanced to have it fail me but twice—in one case of exceptional muscle spasm,

*This is not exactly Kocher's reduction; *in fact*, he described a motion of pure flexion (motion of the arm up and forward, in the sagittal plane) as the second manœuver. The sequence given above is, however, what is usually done as Kocher's reduction.

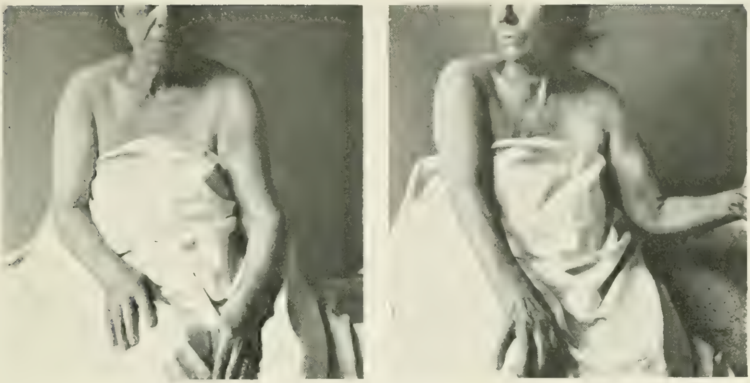


Fig. 149.—Effects of outward rotation alone. An instant after the right-hand picture was taken the head slipped in (author's case). Shows the outward movement produced by rotation.

Fig. 150. Fig. 151.

Fig. 152.

Figs. 150, 151, 152.—Kocher's reduction. Fig. 150 shows the outward rotation movement; in Fig. 151 the elbow is carried forward and to the side, and in Fig. 152 it is pressed across the chest; the arm is then rotated inward.

and in one case of displacement perhaps more nearly intracoracoid than subcoracoid.

I have repeatedly had it succeed after vain trial of other methods.

The method carries no especial risks. I have once seen the humerus broken during the outward rotation, but this was in a case of some weeks' standing;* the accident has, however, occurred in fresh cases, and it is well in old people with brittle bones to use some caution.

Reduction with the Heel in the Axilla (Fig. 156).—This is the method known as Astley Cooper's, though it antedates his time. For its per-

Fig. 153. Subcoracoid luxation produced by abduction and inversion on the cadaver (author's sketch).

formance the patient is laid on his back; the operator presses his heel (without a boot) into the axilla, while he pulls the arm outward at right angles to the body, and then swings it down toward the patient's flank, using his heel as a fulcrum. The operator's body-weight gives

* There are many cases on record. I have myself produced one such fracture in a luxation of four weeks' standing, but the break was a completion of a fracture that had separated the greater tuberosity. The type fracture so produced is apparently a spiral fracture of the "surgical neck."

the pull; the swing of his body gives the force for leverage. The only trouble with this reduction is that a moderately powerful man may readily exert far too much force. The heel pins the soft parts against the bone, and Heaven knows what damage may be done to nerves and vessels and to the short muscles, to say nothing of the chance of breaking the bone at the surgical neck. The damage is greatest, of course, if the attempt at reduction is unsuccessful. There is no doubt that the bone may be reduced by this method, as a rule, but it is a method to be used with caution and as a last resort, not as a routine (Fig. 156).

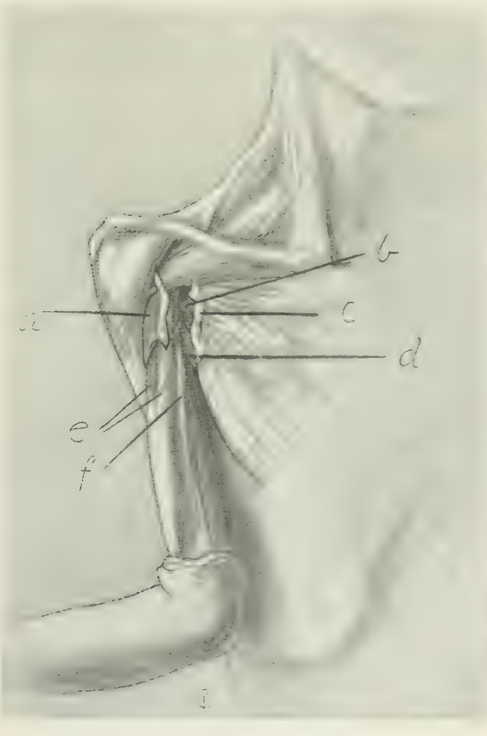


Fig. 154.—Same cadaver as Fig. 153. *a* and *c* show the ends of the pectoralis major, cut to expose *b*, the subscapularis and teres, and *d*, the latissimus dorsi; *e*, *e*, is the biceps; *f*, the coracobrachialis lying directly over the vessels and nerves.

Downward Traction with Leverage.—This is merely a modification of the last—more merciful in detail. The abducted arm is gradually pulled down on and adducted, while an outward pull is exerted in the axilla, or while the assistant pushes his doubled fist into the axilla as a fulcrum. It is the same leverage that is often useful to correct displacement in fracture of the surgical neck. (See Fig. 157.)

Reduction by Outward Traction.—This method belongs more particu-

larly to the reduction of subclavicular displacement, but may be useful with the subcoracoid type. It consists simply of a traction outward on the arm, with countertraction exerted by a sling about the scapula, crossed under the back, with the ends held by the assistant (see Fig. 158), or the operator's unbooted heel in the arm-pit may be used to give countertraction without being used as a fulcrum. Rotation of the arm in or out is here allowable and may be useful. Unless unnecessarily great force is used, there is no objection to this method, and it is rather apt to be serviceable.

There are two other forms of application of this method—the first

Fig. 155. Same specimen. Shows how the subscapularis is tightened and the head moves outward under it on outward rotation.

is the method by elastic traction; in this rubber, bands or springs are applied to the bent elbow in abduction; it is a method in some favor on the continent; the second is Stimson's method of putting the patient on a gas-pipe frame on a hammock, and letting the arm, weighted if need be, hang down through the hammock to reduce itself by gravity. The same mechanism is readily secured by using two tables. (See Fig. 159.)

Reduction by Upward Traction. This method, belonging by right to the downward luxations, and particularly to the "luxatio erecta," is sometimes used for the subcoracoid cases with success. It consists

Fig. 156.—Heel in the axilla.

Fig 157.—Traction downward over arm on hand in axilla as fulcrum.

simply of traction directly upward, with counterpressure from above on the scapula and the clavicle. (See Fig. 160.)

It has the advantage of a maximum relaxation of the coracohumeral ligament.

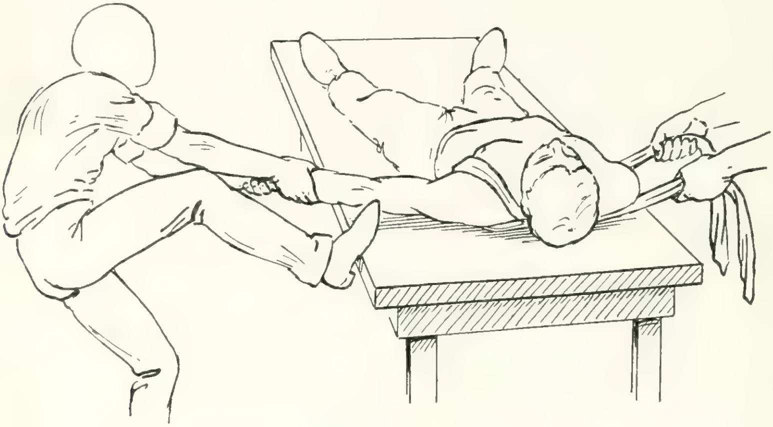


Fig. 158.—Reduction by traction outward with countertraction.

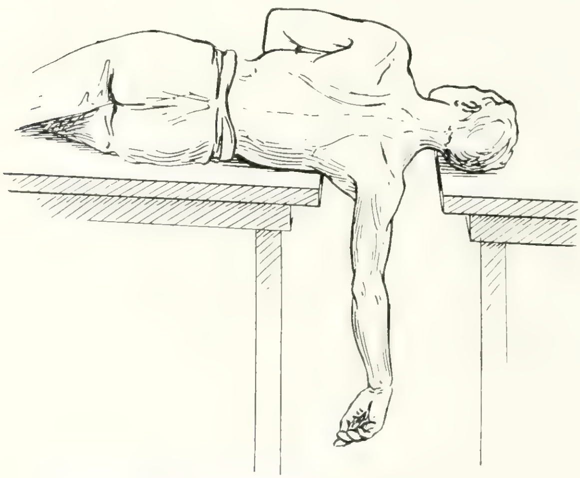


Fig. 159.—Stimson's method of reduction by gravity.

There is one method to be mentioned only for condemnation. This is what we may call the "wrestling-grip." It is an arm grip long known to wrestlers. The patient lies on his back on a table; the operator, back to the patient, grips the arm as shown in Fig. 161, then rotates his whole body toward the feet of the patient.

The force exerted is, in part, one of traction down and out; in part, of a leverage across the operator's pelvis, carrying the head of the humerus outward. In the hands of an expert this method may do very

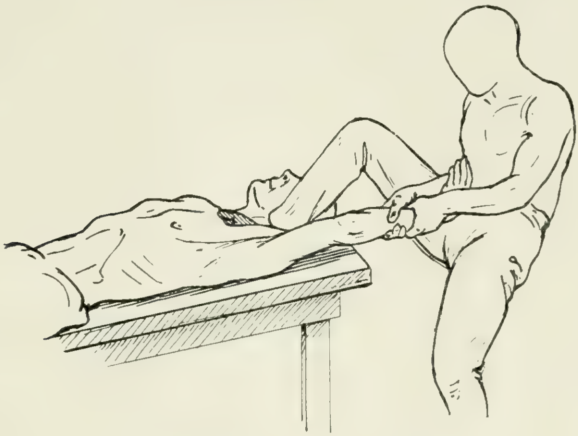


Fig. 160.—Reduction by upward traction.

well; for average use there is so great a possibility of applying enormous force too easily that the method should not be countenanced.

Discrimination of reduction methods according to the complications present seems not to have been established in either anterior or posterior luxations. Such complications are, therefore, still to be regarded only as legitimate excuses for failure and reasons for later operative interference.

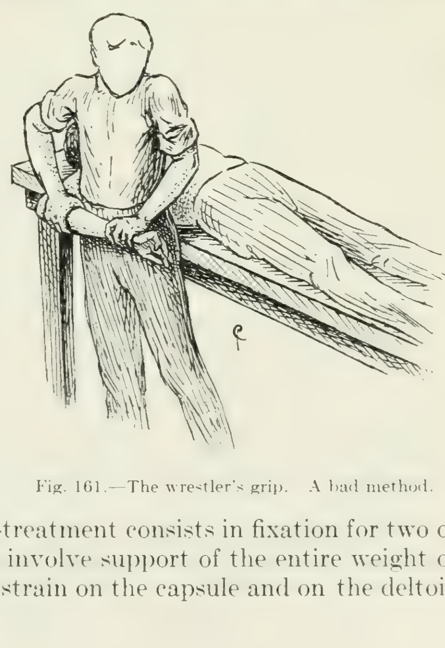


Fig. 161.—The wrestler's grip. A bad method.

Probably in the future some one will study and give to the profession the diagnostic points indicating such complications, and the modifications of methods of reduction adapted to their interference as applied to shoulder luxations—a service comparable to that rendered by Allis in relation to dislocations of the hip.

After-treatment.—The after-treatment consists in fixation for two or more weeks; fixation must here involve support of the entire weight of the arm, else we get undesirable strain on the capsule and on the deltoid and other muscles.

This purpose is best accomplished by the use of the "sling and circular" bandage. I use adhesive for the circular. (See Figs. 162 and 163.) The Velpeau bandage (see Fig. 119) has little more than a decorative value. Exceptionally, the adhesive sling advocated by

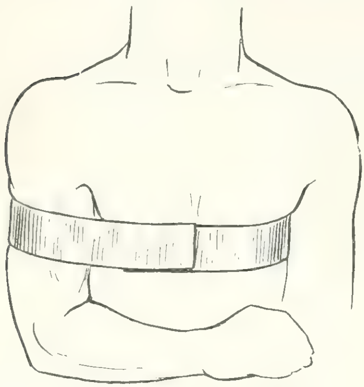


Fig. 162.—Circular adhesive to hold arm still.

Fig. 163.—Sling applied outside the circular to carry the weight of the arm. It should carry *all* the weight.

Stimson for acromioclavicular luxation (Fig. 164) is here of service if the cloth sling will not hold.

Massage and careful passive and active movements may be begun early with profit.

Fig. 164.—Adhesive dressing to support arm. Circular bandage outside it.

Some motion as early as three weeks is almost essential to a good result.

Results.—Uniformly we have for a time much tenderness and much pain on attempted motion. Swelling and ecchymosis vary within wide limits. If we begin massage and motion early, we get, as a rule, a very satisfactory restoration of the range of motion, even in elderly patients. Long fixation jeopardizes this result. There is almost always a rather persistent soreness about the coracoid process, and just below the acromial spine, apparently due to tearing of ligaments. It always wears off with time.

It is fair to say that, except in cases complicated with fracture or with nerve lesions, the restoration of function is usually excellent.

After efficient early reduction of anterior luxations we may expect in the younger patients perfect restoration of function within a few weeks in most cases; there remains at most a certain sensitiveness of

the joint—a little soreness on hard use which may persist for some months.

Recurrence of the luxation, of which much has been written, seems in fact to be a distinctly rare occurrence in cases properly treated; where reluxation is permitted by inadequate protection in the first two or three weeks, or where there has been fracture of the glenoid edge, or fracture of the tuberosities with dislocation or rupture of the biceps tendon, we may, of course, face such a prospect. Such cases are, however, the rare exception.

In case of nerve lesions, whether of the brachial plexus or of the various trunks, the prognosis depends on the power of regeneration of

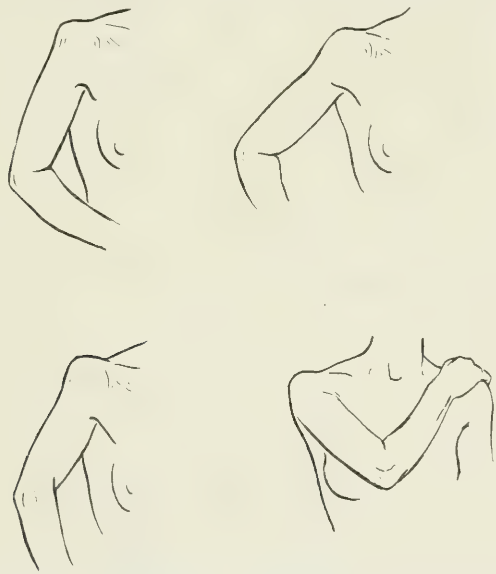


Fig 165.—Shows the range of motion in an *old* unreduced subcoracoid luxation. (Drawn from a case personally observed.)

the stretched nerves and on the care used to prevent stiffening while such regeneration goes on; this means massage, motion, and electric treatment.

Contusion with rupture of the supraspinatus tendon seems, according to Codman's researches,* to be an occasional cause of subdeltoid bursitis—serious, though rarely occurring with dislocations.

Fracture of the tuberosities may give some delay in return of function, but does not seem to be a source of much trouble.

Unfortunately, any of these lesions is likely to prolong the necessary period of immobilization, and such prolongation in itself is apt to be a cause of delayed return of mobility. In older patients this may leave

* Codman, Boston Med. and Surg. Jour., May 31, 1906.

some permanent loss of motion and function. In older patients, irrespective of complications, the return of motion after luxation may be slow and imperfect. Massage with passive motion, properly handled, does much to avoid this.

The last motion to return is inward rotation—the power to put the arm behind the back. Next to this, the power to put the hand to the back of the head is latest in returning. Unfortunately, these motions are peculiarly important to women in dressing and in arranging the hair. They almost always return in time, but often only after a period of some months.

In the rare cases where anterior luxations are unrecognized, or from other causes must remain unreduced, what may we expect as to function? The results are curiously good. Fig. 165 shows the range of motion in one such case—probably a fair case to take as an average. Full motion is, of course, impossible, but the range of motion and of use is surprisingly good.

Also, where there has been fracture of the anatomic or the surgical neck, with the luxation, and no replacement of the fragments, or where such fracture has attended overzealous attempts at reduction, we have a similar condition, and, again, surprisingly good functional results. It has been said that there is in *any* unreduced case some liability of pain from stretching of nerve-roots over the permanently displaced head. As to this, I have no opinion: I know only that such results of stretching *sometimes* persist.

SUBCLAVICULAR LUXATION

This is merely an extreme type of the subcoracoid,* accompanied in some cases, if not in all, by some tearing of the coracohumeral ligament, as well as a more general capsular tear than usually occurs in the subcoracoid type. (See Fig. 141.)

Clinically, the picture is that of an *exaggerated subcoracoid* luxation. The arm stands farther out from the side; the humeral head lies farther in, to the inner side of, or below and in front of, the coracoid process. The hollowing below the acromion is increased, and there is slight *shortening* on measurement. (See Fig. 148.) Limitation of motion is apparently not greater; liability to damage to the various soft parts seems not to be increased, except for increased hematoma and soreness.

Treatment.—Reduction in this form of displacement must take account of the *inward* displacement. Whether the coracohumeral ligament be torn or not, we must first reduce the displacement to that of a subcoracoid, in the course of our reduction. The rent in the

* No account is taken of the form of luxation called "intracoracoid." It is purely a transition form between the subcoracoid and the subclavicular types.

capsule is about the same as in the subcoracoid type; the intact ligaments may be the same or they may not be.

In either case direct traction outward, with the arm at right angles to the trunk, must bring the humeral head under the coracoid process. With the head brought to this point we may reduce by continuation of the lateral traction, or we may resort to any of the procedures above described for reduction of a subcoracoid luxation.

In fact, the usual procedure is a continuation of traction in abduction. If this fails, we may have recourse to *any* of the methods for reducing subcoracoid luxation.

SUBGLENOID LUXATION

Whether this is a rare or a common type is *purely a matter of definition.* The head of the humerus in this type simply lies nearer the *lower edge of the glenoid.* If we establish as a clinical distinction that a proper subglenoid luxation should leave the head more readily palpable in the axilla *behind* the greater pectoral than in front of it, then subglenoids are rare.

I know no better dividing line, and on this basis should call the subglenoid types rather uncommon.

Fig. 166.—Subglenoid luxation, with fracture of the anatomic neck (impacted) and of the greater tuberosity (*x*-ray by Dr. Van Allen).

Etiology.—Etiologically, they result usually, perhaps always, from hyperabduction on a fulcrum either of the acromion or of the resisting adductor muscles. Probably this lesion does not occur from direct thrust on the elbow.

Lesions.—Pathologically, they show no peculiar character except that the tear of the capsule lies a little lower than in the subcoracoid types. The subscapularis is ordinarily not involved.

Symptoms.—Clinically, they show a sharper abduction than the subcoracoid type, a somewhat different attitude of minimum discomfort. (See Figs. 142 and 168.) Beyond this we have only the slight shortening (measured from acromion to external condyle) and the presence of the head (palpable in the arm-pit) as guides.

Reduction.—Reduction is ordinarily possible by any method applicable to the reduction of the subcoracoid type, but the form of proce-

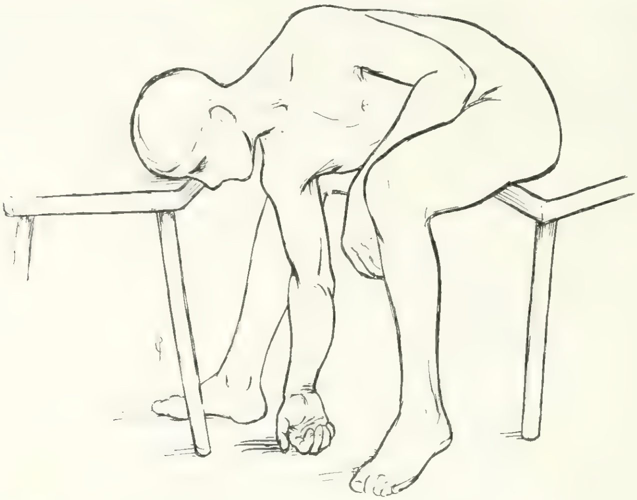


Fig. 167.—Subglenoid luxation; attitude of minimum discomfort assumed by a case of the author's.

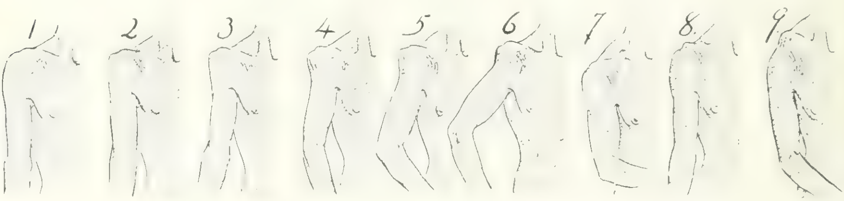


Fig. 168.—Attitudes in various shoulder injuries: 1, Normal; 2, fracture of anatomic neck; 3, fracture of surgical neck; 4, separation of epiphysis; 5, subcoracoid; 6, subglenoid; 7, fracture of clavicle; 8, acromioclavicular luxation—usual form; 9, same, with much tearing and displacement.

dure probably most advisable is that of lateral traction combined with upward pressure on the humeral head. If this fails, *upward* traction, with pressure on the head, should lead to success.

LUXATIO ERECTA

This is the type in which the arm is directed upward, close to the head, the hand usually resting on the head.*

The type is excessively rare. The cause is extreme abduction, accompanied sometimes with a blow on the humeral head from above. In one case, at least, on record in the literature there was an associated acromial fracture.

* Montgomery, Ann. Surg., 1905, xli, 475, records one of the few recent cases.

The condition is one of a subglenoid or axillary dislocation, in which the head is *driven down to an extreme extent*, while the intact muscles and ligaments, acting as a lever of the second type, hold the arm in extreme abduction.

Very extensive tearing of ligaments is probably the rule.

The diagnosis is obvious.

Reduction is by traction *upward* and by direct pressure on the head. Reduction seems to have presented no peculiar difficulty in the recorded cases.

The prognosis differs from that of ordinary luxations only in the greater probability of injury to the circumflex nerve.

Fig. 169.—Luxatio erecta (diagrammatic).

SUPRAGLENOID LUXATION

This lesion is so rare as to be almost negligible. Many of the recorded cases were observed so late as to be invalidated, so far as details go. There are, however, certain cases, such as that of Holmes* (an autopsy at five weeks after injury), which establish the type.

In this case there was a broken coracoid, the humeral head was plunged upward and forward through the deltoid muscle, the capsule was extensively torn at the upper and inner part, and the biceps tendon, untorn, had slipped outward.

Fig. 170.—Supraglenoid dislocation, with fracture of the acromion (diagram).

Other cases recorded show an associated fracture of the acromion.

The total of alleged cases on record is considerable; many of them, however, were examined only long after the original injury.

So far as we know, this lesion necessarily occurs from a direct thrust upward and forward, exerted through a blow on the elbow. The diagnosis must be obvious, even on inspection. The only question would be that of displacement of the humeral shaft up and in, with fracture of the surgical neck or with epiphyseal separation a question readily solved. Obviously, the mode of reduction would be by traction down and backward.

There seem to be no fresh cases on record, so that we may advance no argument for such plan of reduction other than its reasonableness.

INWARD OR INTRATHORACIC LUXATION

A very few cases are recorded in which the head of the humerus has been driven inward through the chest-wall. These correspond in a

* Holmes: Med.-Chir. Trans., 1858, xli, p. 447.

way to the luxations of the femur through the acetabulum. They must occur from direct inward thrust, exerted through the abducted arm by a blow on the elbow.

The diagnosis depends on the marked abduction with fixation and shortening, on the presence of thoracic symptoms, and on the absence of the humeral head on the outside of the thorax.

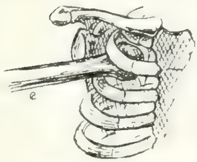


Fig. 171.—Intrathoracic luxation. Penetration of the thorax by the head of the humerus. The ribs may or may not be broken (diagram).

Usually, one or more ribs are broken by the passage of the head.

Cases are on record in which the ribs have been *forced apart,* not broken.

Reduction and Treatment.—The treatment must be obviously by right-angled traction, with rotation and rocking to bring the humeral head out again from the thoracic cavity to a position external to the ribs. From the stage where the head emerges from the thorax we have to deal with what is practically a subglenoid luxation, to be handled in the usual way.

POSTERIOR DISLOCATIONS

Of these, we have the types described as *subacromial* and *subspinous,* differing only in degree of displacement, showing essentially the same deformity, amenable to the same schemes of reduction. Both are but rarely met with as actual results of trauma. "*Congenital*" luxation backward is not rare.

Etiology.—These luxations occur from backward thrust, favored by rotation inward, by elevation, or by adduction. They occur from falls, or, not very uncommonly, from muscle action suddenly, as in the extreme spasm of epileptic convulsions, or slowly, from the prolonged unbalanced muscle pull in cases of obstetric or infantile paralysis.

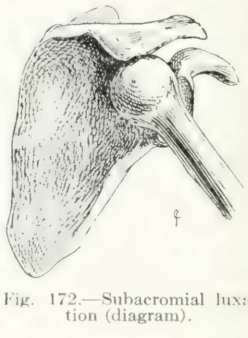


Fig. 172.—Subacromial luxation (diagram).

Pathology.—The rent in the capsule lies posteriorly—across the back of the joint, below the insertion of the supraspinatus muscle. The tendons or the muscle bellies of the short external rotators may be torn. The subscapularis may be torn (Cooper). Sometimes the greater tuberosity, torn loose, remains in its relation to the glenoid cavity, not to the head; the biceps tendon may be torn out of its groove. (See Fig. 173.)

Symptoms.—Clinically, we have the head of the bone palpable behind its normal position, and its normal prominence above and in front is replaced by a flattening or hollowing. The arm is, as a rule, raised up

and forward and rotated inward, with more or less adduction; there may even be adduction across the chest, so that the hand rests most

Fig 173.—Thirty-foot fall; died, after reduction, of other lesions. Capsule destroyed above; greater tuberosity fractured split and displaced. Biceps tendon had torn out of groove (sketched from Malgaigne's pl. xxii, Fig. 5).

comfortably on the head. We may, on the other hand, find the elbow closely appressed to the chest.

In general, moderate adduction characterizes the subacromial type; the subspinous type involves rather an abduction and an *increased* separation of the elbow from the side. The case in Fig. 175 shows the subacromial type.

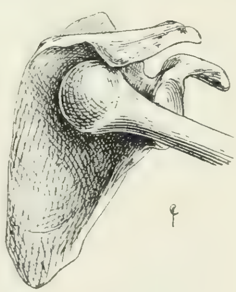


Fig. 174. Subspinous luxation (diagram).

There seems to be, judging from reported cases, a good deal of variation in the deformity with either type. With either type there is, of course, a sharp limitation of the range of motion.

Reduction proceeds along obvious lines. Traction on the arm in its long axis, combined with alternating outward and inward rotation and with rocking movements, seems to have sufficed to reduce the cases on record. Digital pressure forward on the protruding head is of some importance. Adduction of the arm helps to clear the humeral head, so that it may pass over the posterior glenoid edge. Raising the arm up and forward and inward rotation all tend to relax the taut ligaments and to aid reduction.

Recurrences are reported in some number in cases supposed to be traumatic. Obviously, in "congenital," paralytic, epileptic, or other

Fig. 175.—Posterior luxation. Subacromial type, unreduced for several months (author's case, negro woman of fifty years, luxation due to epileptic convulsion).

spastic cases recurrence may be counted on unless we do an open operation, and perhaps then.

That recurrence should occur in a case like that of Cooper's in which the subscapularis was wholly torn off need excite no remark.

COMPLICATIONS—FRACTURES

Fractures that may complicate shoulder dislocations are those of the glenoid, acromion, coracoid process, greater tuberosity of the humerus, lesser tuberosity of the humerus, anatomic neck of the humerus, surgical neck of the humerus.

Fractures of the glenoid are not very rare; they involve only the

anterior edge of the glenoid, as a rule.* Such fractures do not interpose any obstacle to reduction, but do predispose to recurrence. Fractures of the glenoid involving more than an edge of the glenoid cavity, fractures approaching the surgical neck of the scapula, are a rare complication of dislocation. I have seen but one case of this sort. It did not interfere with reduction, but shared with a deltoid paralysis that accompanied it in the causation of an extreme dropping downward and forward of the reduced head of the bone. Apart from the x-ray we have no means of diagnosis of glenoid fracture save for crepitus and the tendency to immediate reproduction of the deformity after reduction.

Fractures of acromion or coracoid occur rarely, but seem to offer no difficulty in reduction and no influence on prognosis. The interest centering in them is practically one of differential diagnosis of such fractures as against others in this region which are of greater clinical import. They may accompany practically any of the described types of luxations.† The diagnosis rests on local tenderness and ecchymosis, on crepitus, and on palpation of the loose fragments.

Separation of the greater tuberosity, not uncommon, gives more or less crepitus, and may give a palpable loose fragment near the empty glenoid. It is relatively unimportant except in so far as imperfect (fibrous) union *may* give some weakness of the muscles that raise the arm and rotate it outward, and in so far as resultant thickening *may* impede motion. Apparently the separation between the adherent tuberosity and the wandering head has no especial bearing on the ease of reduction or on the method to be employed in reduction.

Fracture of the lesser tuberosity (rare) might be dismissed in the same phrase, were it not that such fracture liberates the biceps tendon from its groove, and may permit displacement of this tendon or possibly its interposition in the way of reduction.‡

Presumably any such displacement of the lesser tuberosity is likely to be rather out of than in the way of the dislocation§—and of its reduction; *i. e.*, the muscles will probably pull it out of the way.

Fractures of *either* tuberosity tend, on the whole, to *slight* displacement only, since the periosteal and ligamentous connections are close.

* Some separation of part of the *cartilaginous* glenoid edge is probably even commoner than fracture.

† Malgaigne (Atlas, Plate XXII, Fig. 4) figures a specimen found in the dissecting room with an unreduced subcoracoid luxation and an unrepaired coracoid fracture. The displacement was trifling so far as the coracoid was concerned.

‡ A couple of very interesting cases of displacement of the biceps tendon by muscle action, without dislocation or fracture, are reported by Hennequin and Loewy (Les Luxations des Grandes Articulations, Paris, 1908, pp. 60, 61). In one case reduction occurred on abduction and inward rotation. The diagnosis rested on pain on abduction and on outward rotation, and on direct palpation of the cord of the displaced tendon.

§ In a case of my own there was a subcoracoid luxation with a T-split running between the tuberosities. The biceps tendon had slipped into the split. It had to be divided to allow reduction: it was then sutured.

Ordinarily these complications are important only in the differential diagnosis as against simple fractures of the anatomic or surgical neck, and in so far as they affect prognosis of the eventual usefulness of the arm.

Fracture of the anatomic neck complicating luxation seems to occur very rarely (Fig. 176; see also Fig. 178)*; the differential diagnosis between such fracture alone and luxation alone will be considered later.

Fracture of the surgical neck complicating dislocation does occur, and is a most formidable complication. The cases recorded are nearly always of anterior luxation. Some few result from overvigorous attempts to reduce luxations.

Obviously, the breaking-off of the head

Fig. 176.—Fracture of the anatomic neck, with chipping of the tuberosities, complicating luxation. Old case. Head excised: fair result.

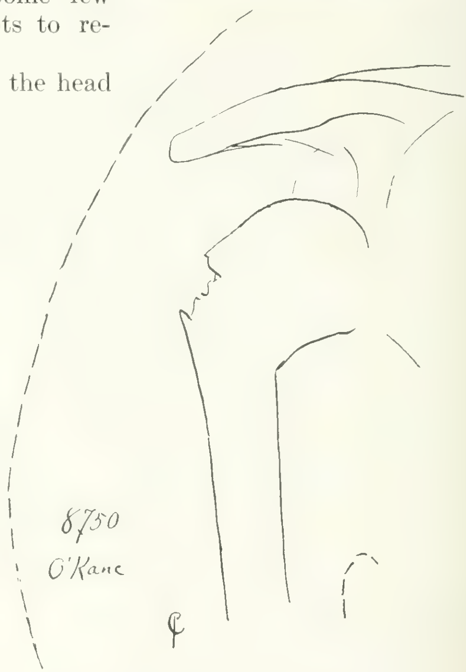


Fig. 177.—Subluxation with fracture of the tuberosities and surgical neck.

of the bone throws out all diagnostic points usually indicating luxation. To all intents and purposes we have an apparent fracture of the neck. The important fact of a dislocation of the head is discoverable only by the *absence of the head from its normal site* and the actual *presence of this head palpable outside the socket,* and

* Since the above was written I have seen a second case with a displacement of the head under the coracoid process, with the tuberosities lying in the glenoid cavity. The case was not seen until seven weeks after injury. Owing to pressure on nerves, the head had to be removed.

unaffected by motions of the shaft. Crepitus may be present or it may not.*

Obviously, all our methods of reduction are of little use in this condition; it is possible that enough connection of fragments may be retained to permit of reduction by right-angled traction, with outward pressure on the head. Successful issues of this manœuver are recorded in some number. If this fails, the ancient and classic method advised is to wait for union of the fracture and then to reduce.

This is hardly rational or encouraging; the more so as these cases, unreduced, may show not only the troubles of poor joint function, but pain from the direct pressure of the displaced head on the nerves as well.

If such attempt at reduction does not succeed, as it usually does not, there is nothing for it but to operate.

Operation has been done in a number of cases, and with gratifying success, by many others besides myself. The problem is simply to cut down upon the bone at the point of the break, and to reduce the head of the bone to its normal position with the least possible manipulation of the injured parts. McBurney, years ago, devised a simple but ingenious method, consisting of the use of a right-angled traction hook, inserted into a drill-hole at the lower end of the upper fragment. This manœuver renders rotation and traction perfectly simple, with but little handling of the parts.

Fig. 178.—(Same plate as Fig. 166.) Fracture of anatomic neck and of tuberosity, with luxation.

This procedure was used by McBurney with a perfect result in a case first seen two weeks after the injury. This was in 1894.† The method has been used several times since with excellent results if interference is undertaken *early*.

The incision to be used is the anterior, reaching the joint through

*Not uncommonly we may find in the x-ray an *apparent* dislocation of the head with fracture of the surgical neck. In fact, these seem rather to be subluxations. Fig. 177 shows such a case. There was no real luxation disclosed at the operation.

†C. N. Dowd: Annals of Surgery, 1894, i, 399.

the interval between deltoid and pectoral, severing no muscle, and imperiling no vessels or nerves.

There is no question but that this method should also be used in the cases where the humerus has been broken in attempts at reduction.

Unfortunately, considerations other than the simple surgical ones often prevent its use where such an accident occurs.

In cases where luxation coexists with fracture, whether from the original injury or following a break during attempted reduction (Fig. 179), the

Fig. 179.—Fracture of the shaft high up, following an attempt to reduce an old subglenoid luxation. This fracture was wired. Some months later I saw the case and reduced the luxation by open operation with partial resection of the head. Rather good result.

Fig. 180.—Subcoracoid luxation, with avulsion of the greater tuberosity, before reduction.

results are surprisingly good, even if nothing is done. The shoulder is necessarily a relatively stiff one, but the humerus becomes fixed at such an angle that the elbow no longer stands out from the side, and the scapula, as always with a stiff joint at the shoulder, gains so much mobility as to give a very fair range of motion to the arm—sufficient for many kinds of work. If there is non-union, the pseudarthrosis will give a very tolerable joint unless there is marked secondary arthritis.

NERVE LESIONS

Damage to nerves is lamentably common in luxations—commoner than is usually realized.* We may have tearing of the brachial plexus

* Holm (Schmidt's Jahrb., cxxi, p. 82) cites a series of 112 luxations with no less than 7 cases with general paralysis of the arm, and 10 with deltoid paralysis alone. Tubby and Jones (Surgery of Paralyses, 1903, p. 248) cite 38 cases of nerve and

in the neck (Fig. 181), due to the same violence that causes the luxation,—not to the luxation itself,—or we may have damage to any or all of the nerves, caused by their being stretched over the luxated head; or we may have injury to the circumflex nerve alone,* due to stretching

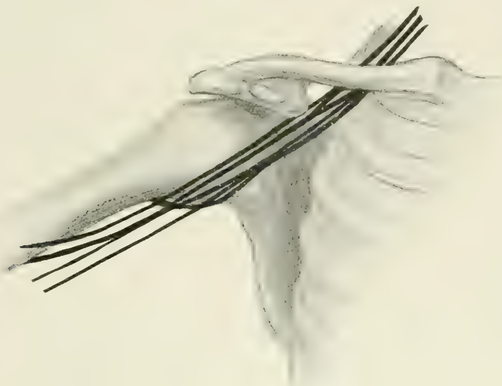


Fig. 181.—Relation of the trunks of the brachial plexus to the head of the humerus. Note how closely the circumflex wraps around the neck, and how high up the musculospiral runs to the back surface. The damage with any displacement of the head may be from either push or pull.

Fig. 182.—The course of the circumflex nerve around the neck of the humerus, seen from behind.

of this nerve by the simple displacement of the humeral head, just below which it is so closely entwined about the shaft (Fig. 182).

vessel injury. They attribute the injury to reduction by the "heel in the axilla" method in 29 of these cases.

Müller (Centralbl. f. Chir., 1892, p. 611) notes a case of *gradual* paralysis from *scar pressure*, verified by operation.

* In cases where anterior luxation results from a fall on the shoulder it is not easy, even for a neurologist, to discriminate between the direct results of deltoid contusion and the circumflex lesion. This is because of the difficulty of electric stimulation of the deeply situated nerve. Both lesions are serious; both ordinarily recover with time if no other paralyses are present.

Any of these injuries may result from overzealous attempts at reduction, as well as from the first trauma.

The frequency with which even the more serious forms of nerve damage are entirely overlooked at first is the only reason for the series of plates appended (Figs. 183 to 189).

In regard to these nerve injuries, it is perhaps fair to say that our first interest may rightly be that of self-protection. They may result from the luxation or from the reduction, and the first thing we should attend to after establishing the diagnosis of any luxation is an investigation of the condition as regards the nerves, a testing of motor function and of sensation in the arm and hand. If this were more regularly done,

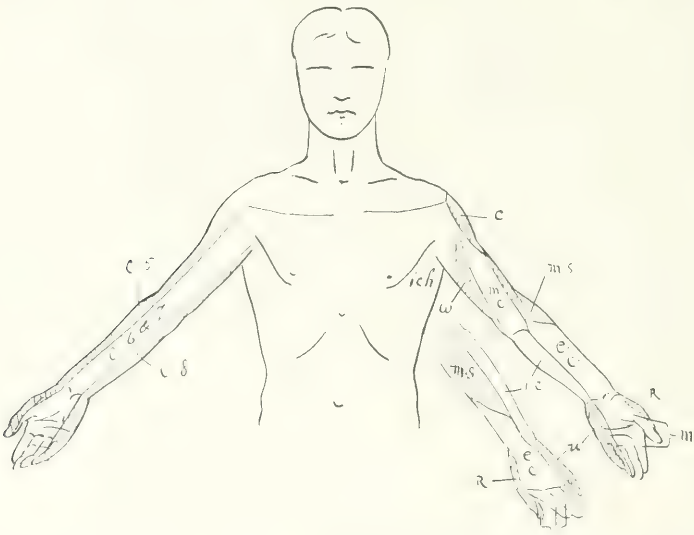


Fig. 183.—Sensory areas. On the left are shown the areas corresponding to the fifth to the eighth cervical *segments* of the *cord;* on the right, the areas of distribution of the *nerves:* *c*, Circumflex; *ich*, intercostohumeral; *m.s*, musculospiral; *m.c*, musculocutaneous; *w*, nerve of Wrisberg; *e.c.*, external cutaneous; *i.c.*, internal cutaneous; *r*, radial; *m.*, median; *u*, ulnar.

there would be far less blame attached to the profession for alleged production of really *inevitable* nerve injuries, due to the trauma and *not* to the reduction.

Given an injury of one or more nerves, we must face the question of *treatment.*

If the brachial plexus has been *torn*, operation and suture of the torn ends are indicated. Unfortunately, the prognosis is bad either way, but it is better with than without operation. In lesser injuries no treatment beyond that of massage, electricity, etc., is ordinarily called for.

It has been my fortune, or misfortune, to see in the last three years seven cases of serious injury of this sort, apparently due not to efforts

at reduction, but to original trauma, in four of which the united efforts of my neurologic colleagues and myself have accomplished little.*

Figs. 184, 185.—Old subcoracoid luxation, with extensive motor paralysis of the left arm and shoulder (brachial plexus or root lesion). Note the atrophy and the downward dropping of the arm. Regained some power under treatment.

Fig. 186.—Old subcoracoid luxation. Very nearly total nerve lesions as to motor power. Note the atrophy and the down and forward droop of the shoulder away from the acromion. There was little if any improvement in this case from any treatment

One case resulted in practically perfect recovery; in two recovery was creditable—at least one is still improving, but by no means perfect; one I have lost track of.

It may be said that a failure of the power to abduct the arm, a paralysis of the deltoid (whether due to nerve injury or muscle contusion) is not rare, and not necessarily very serious.

Such a degree of paralysis of the deltoid, however, as results in an obvious dropping-away of the humerus from the glenoid socket, is serious.

I believe such a "downward dislocation" occurs *only* as a result of such paralysis.

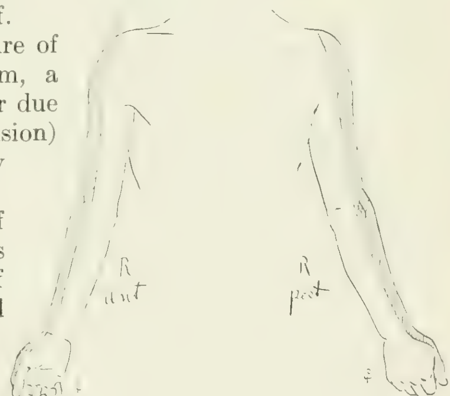


Fig. 187.—Shows the sensory loss in the case shown in Fig. 186.

Some of these cases of paralysis, even if severe, recover in time more or less completely, but we do meet with cases of

* Stimson's statement that "Injury to the nerves, except of a slight and transitory character, is rare, and in most of the cases reported as such the injury has been inflicted during reduction," is one with which I am reluctantly compelled to differ. No doubt in old cases reduction is the great danger,—and this is an argument for open reduction,—but I have seen cases repeatedly in which prompt paralysis *preceded* reduction or was present after the most careful and simple reductions. I confess, however, that I personally saw none of these before reduction.

permanent motor impairment—cases in which we can do little more than establish our innocence as to any blame for the unfortunate result.

Figs. 188, 189.—Old dislocation of left shoulder (subcoracoid), with loss of motor power corresponding to nearly all branches of the brachial plexus. Only moderate improvement after long and patient treatment. Note the great deltoid atrophy.

In all these cases there is a stiffening at the joint, due to the inevitable disuse, that affects prognosis even if muscle power is regained.

COMPLICATIONS—VESSEL RUPTURE

Axillary Artery.—Very, very rarely the axillary artery * may be torn by the luxation or by forcible attempts at reduction, though such damage more commonly points to fracture.† The signs are failure of the radial pulse and the prompt appearance of an enormous hematoma; sometimes this hematoma pulsates.

The indications are obvious: immediate compression of the subclavian artery where it crosses the first rib behind the scalenus anticus, prompt incision and ligation of the torn artery, with subsequent reduction of the luxation. Even asepsis must give way to the urgency of the operative relief of this condition.

There may, or may not, be sufficiently prompt establishment of collateral circulation to save the arm or the hand from gangrene; either way the surgical indication is the same.

Schmidt ‡ records a case in which axillary aneurysm resulted from *partial* lesion of the vessel in luxation.

Stimson states that both circumflex and subscapular arteries may be torn.

* Stimson in 1885 found 47 cases on record of vessel rupture associated with shoulder luxation, and says he has known of at least two cases since then.

† Loss of radial pulse alone in luxation or in fracture about the shoulder does not prove, though it suggests, vessel rupture. Pressure of displacement often lessens and may obliterate the radial pulse.

‡ Beit. z. klin. Chir., 1904, xliv, 497.

Tearing of the Axillary Vein.—This may occur in the same way. The hematoma is less, and is less immediate in its appearance. The indication for interference is the same; the prognosis as to reëstablishment of circulation is somewhat better. Cyanosis and swelling may persist for a long time.

COMPOUND LUXATION AT THE SHOULDER

This is an excessively rare accident. The penetration of the humeral head occurs most often in the axilla, but the head may be driven through the pectoral muscle, or even backward.

Obviously, the complication is important only in regard to nerve injury, to excessive displacement, and to sepsis. So far as sepsis goes, there is no excuse today for such a prognosis as would appear from the cases recorded in the literature, so it is not worth while to discuss statistics.

Active antisepsis is obviously in order. Whether the given case calls for drainage must rest with the surgeon's judgment. Here, as elsewhere, it is safe in doubtful cases to drain—to drain with gauze for twenty-four to forty-eight hours—*not longer.*

OLD CASES OF SHOULDER LUXATIONS

Not rarely old luxations—overlooked, in the rule—present themselves to us. Reduction of such cases is not easy and presents definite obstacles.

*Obstacles.**—Strong adhesions may exist between the new cavity and the neck and head of the humerus. After a long time there may be bony changes, including the formation of an actual new glenoid cavity of bony tissue. (See Figs. 139 and 140.) There may be marked shortening and rigidity of the muscles. There may be such entire healing of the rent in the capsule, through which the head escaped at the time of injury, as to make the reëntry of the head impossible. There may be firm adhesions between the capsule and the glenoid cavity. This process may uncommonly have gone on to the point of entirely filling up the cavity, leaving no place into which the head may be returned. Of course, these difficulties may occur not singly, but combined.†

The amount of actual difficulty that each of these complications, or all of them combined, will offer in attempts at late reduction must depend largely on the time elapsed since injury.

* Souchon (Trans. Amer. Surg. Assoc., 1897, p. 311) collected 154 cases, admirably showing the obstacles to reduction in both fresh and old luxations at the shoulder. His monograph is a notable one.

A more recent article, dealing exhaustively with the question of hindrances to reposition, is by Bach (Deut. Zeit. f. Chir., 1906, Bd. lxxxiii, p. 27).

† In one of my cases the x-ray showed fracture of the surgical neck and a split between the head and the tuberosities. Operation disclosed the biceps tendon

These represent the mechanical difficulties that oppose themselves to late reduction. They do not, however, measure the difficulties of late reduction, for such procedure carries not only difficulties, but actual dangers the danger of fracture or of damage to vessels or nerves during manipulation.

Worst of all is, of course, the rupture of the axillary artery. This is not an extremely rare accident. It occurs from the traction on adhesions which have involved the vessel, which have so glued it down to the humerus as to expose it to a tearing strain on reduction. The presence of arteriosclerosis is, of course, a favoring factor in such rupture. Within ordinary limits of force used it is a question not so much of the manner of reduction as of the lesions previously present. Liston* cites a case in which there was a firm fibrous band uniting coracoid process and humerus with an intimate connection with the sheath of the axillary artery.

Fig. 190.—Old subcoracoïd luxation of right shoulder. The photograph shows little; palpation left no doubt of the lesion; it was confirmed by the *x*-ray. Disability was extreme.

This occurred after only eight weeks. The artery, which was somewhat atheromatous, was ruptured in reduction, and despite the prompt operation which was performed, the patient died. The operation was an excision of the head of the humerus after securing the artery at the point of rupture. The conditions found at autopsy in this case are of interest; a broad and strong band of fibrous tissue connected the humerus with the coracoid process, and also with the sheath of the axillary artery which lay above it. The vessel was, therefore, necessarily subjected to traction, because it was no longer movable in its sheath.

This case, which is by no means an isolated instance, must be placed over against the cases reported in which late reduction has succeeded.

Reduction without incision is dangerous.

dropped into this interval. Only by section of the tendon was reduction made possible. The tuberosities were held in place with a steel pin; the tendon was reunited in part. The result was excellent.

* Edin. Med. Jour., March, 1873.

I am inclined to favor operative reduction of old luxations, as a routine, but from results published and from cases I have operated and have seen, it is impressed on me that we can expect, not perfect results, but at best a *serviceable* improvement in function.

In cases where there is fair function with the head out of the socket we may well pause and consider what operation has to offer.

Here and in other old dislocations our rules of procedure have still to be modified by the greater safety of modern aseptic work. It is probably safe to say that, in patients able to stand an anesthetic comfortably, few risks attend the open procedure. With this open procedure we avoid not only the vitally serious danger of rupture of vessels and nerve trauma, but also the unfortunate fractures of the humerus which have so commonly attended attempts at reduction long after injury.

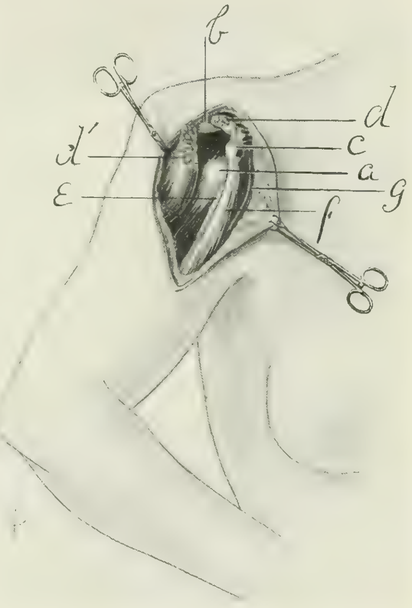


Fig. 191.—Detail of operation on the case shown in Fig. 190: *a*, Greater tuberosity; *b*, front of acromion; *c*, coracoid; *d*, *d′*, deltoid (cut edges); *e*, biceps tendon; *f*, biceps and coracobrachiales; *g*, vessels and brachial plexus.

Moreover, in an open wound nerves, as well as vessels, may be retracted; without the inspection possible through the wound we do not know where they are, and whether or not they are stretched across the head or dragged on by adhesions. Nerve injuries associated with dislocation are not rarely the results of attempts at reduction, especially in these late cases.

In case open operation is done, access to the joint is most readily obtained by the anterior incision between the deltoid and the pectoral muscles, an incision which exposes the neck of the bone and gives good access to the displaced head. Before reduction some division of the capsule or of the adhesions which bind the head below the coracoid will be necessary. In accounts of operations published it is often stated that the subscapularis tendon is divided. As a matter of fact, in these old cases the distinction between tissues is largely lost and the anatomic structures next the joint are hardly to be made out. What we do, in fact, is to cut fibrous tissue on the inner side of the head until the head is free. We cut the capsule, true or false, which covers the head, and

enlarge a way by which the head may return between the glenoid cavity and the posterior part of the capsule which lies over the cavity.

The filling up of the glenoid cavity by anything firmer than light adhesions is a very late, not an early result, and such adhesions will not ordinarily interfere with reduction. In certain cases there may be serious difficulty in reducing the head or in securing a satisfactory bed to replace it in. In these cases, rather rare ones, it may be well to consider an excision of the head of the bone. (See Fig. 179.) So, too, in cases like that above noted, operated on for rupture of the artery, or in cases where the brachial plexus, already stretched, is likely to sustain serious injury during reduction, excision may also be called for (p. 178, footnote).

In choosing excision rather than reduction we must, however, be prepared for a functionally imperfect result.

Late results in the unoperated case may give a stiff joint, but excision often gives one so weak as to be of no great use except for elbow and forearm work. Cases of excision in which there is any power of abduction that is *practically useful* are not the rule. This is because the head of the bone is a necessary fulcrum.

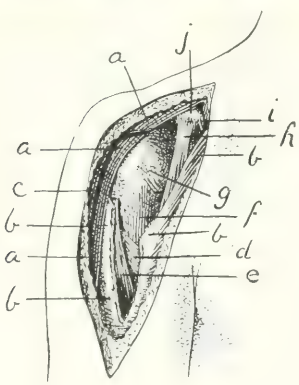


Fig. 192.—Burrell's operation for "reefing" the capsule in recurrent luxation: *a*, Deltoid; *b*, pectoral divided; *c*, cephalic vein; *d*, lat. dorsi; *e*, long biceps head; *f*, shaft; *g*, subscapularis and anterior caps.; *h*, biceps, short head; *i*, pectoralis minor; *j*, coracoid.

It is interesting to note, however, that in the cases of operative reduction reported even an extensive removal of the tendons from the head of the bone, as in some cases that Lister has reported, seems not to interfere with the good result, as attachments are reformed, and the muscles take up their work in better fashion than would be expected.

RECURRENT LUXATIONS

Recurrent luxation is rare compared with the great frequency of primary dislocation at the shoulder.

It has been assumed that a chipping of the glenoid is the cause,* but this by no means is proved as the rule. There is an obvious connection between tearing of muscle attachments and reluxation, but it is hard to demonstrate clinically. Defects of the head of the bone (traumatic?) have been reported repeatedly.

In the rule it is the anterior luxation that recurs, and the displacement happens in abduction.

Replacement is easy.

* Southam (Brit. Med. Jour., 1892, ii, 1192) records a case of this sort. He did an excision—and a postmortem.

Avoidance of abduction may suffice to avert luxation. I know of one subject of this trouble who used an elbow-strap fastened to his belt to insure against abduction, and with success.

If the displacement occurs often, operation is indicated. The operation is a "reefing" of the capsule reached through an anterior incision. (See Fig. 192.)

Burrell* and others have had excellent success with this operation.

PATHOLOGIC LUXATION

Such luxations are rare at the shoulder except as the result of paralyses or spastic conditions that disturb the muscle balance. The result of such disturbance, in "infantile" cases, is noted under *congenital* luxations.

A like result from syringomyelia is recorded in the Deutsche Zeitschrift für Chirurgie, 1905, lxxx, 165–179.

The author has seen one case in which luxation was obviously determined by muscle atrophy about the shoulder in an epileptic, and two in which infantile paralysis in children was the apparent cause of a *posterior* luxation. Luxations in epileptics *without* record of such atrophy are recorded in some number in the literature.

CONGENITAL LUXATIONS

These are not excessively rare. Almost always they are posterior luxations.

R. W. Smith† recorded and figured certain cases of *anterior* luxation, also, apparently congenital.

No doubt these, and certain of the backward luxations, are really congenital developmental deformities analogous to those seen in the hip.

Certain other cases may result directly from damage in delivery at birth—damage involving chipping of the glenoid or damage to the nerves only.

Some of these cases unquestionably result from disturbed muscle balance, congenital only in the sense that the obstetric paralysis causing them dates from birth.

Beside these, some few cases seem to be dependent on the muscle paralyses of anterior poliomyelitis occurring in early life, though in no sense congenital.

In some of these paralytic cases reduction, with incident cutting

* Burrell and Lovett (Trans. Amer. Surg. Assoc., 1897, p. 293).
Legueu, Picque, and others have recorded more recent cases (Bull. et Mem. Soc. de Chir. de Paris, 1905, xxxi, p. 564). There are many others on record.

† Fractures in the Vicinity of Joints, etc. Dublin, 1850, p. 256.

of contracted pectoral and other muscles, has given improved function. In others, as in Phelps' series, excision has been called for, with good function as the sequel. I have had two such cases: one was reduced on section of the contracted pectoral and got fair function; the other was reduced only after partial resection of the humeral head, but the result was relatively good.

RUPTURE OF THE BICEPS TENDON

This rupture may accompany luxation, though but rarely. Not very commonly, however, such rupture—a rupture of the long head which runs over the head of the humerus—gives a condition which may be confused with subluxation.

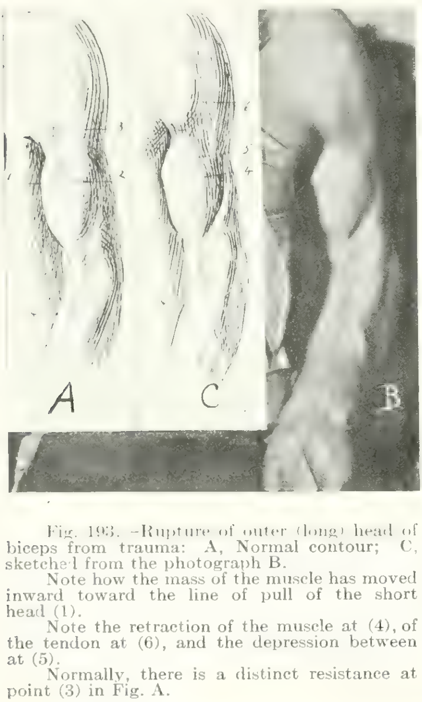


Fig. 193.—Rupture of outer (long) head of biceps from trauma: A, Normal contour; C, sketched from the photograph B.
Note how the mass of the muscle has moved inward toward the line of pull of the short head (1).
Note the retraction of the muscle at (4), of the tendon at (6), and the depression between at (5).
Normally, there is a distinct resistance at point (3) in Fig. A.

The condition is, in fact, a subluxation of minor grade. The biceps tendon is one of the forces making for the fixation of the humeral head in its place. If the tendon is ruptured, the head tends to slip forward.

Rupture of the biceps occurs from all sorts of trauma that involve sharp contraction of this muscle. Usually it happens in middle-aged men, mechanics or others, who, by heavy work, have acquired an unrecognized "occupational" arthritis. Probably the tendon has already been abraded—at all events, it gives way under strain. On examining we find that voluntary resisted flexion of the elbow gives no tension at the site of the long tendon. The mass of the muscle shifts inward, and we have a contour such as is suggested in Fig. 193. The bulging of the muscle below the tear increases with time. We may have well-marked ecchymosis along the course of the tendon after a few days.

With the rupture of this tendon the humeral head very distinctly tends to move forward with any muscular exertion; it moves not into a position of luxation, but of subluxation; the anterior prominence is, however, well marked.

Operations for suture of the ruptured tendon have been done with success. As a rule, however, in the individuals in whom this accident occurs, no longer young and usually much worn, operation is not advisable. The halving of the power of the biceps is tolerable; the operation presents some risk.

BURSAL LESIONS

The relation of lesions of the bursæ to shoulder injuries has not been worked out adequately.

Codman* has shown how adhesions in the subdeltoid bursa affect motion at the shoulder, and has also indicated the rôle played by partial tearing of the supraspinatus tendon in causing bursal lesions.

Stimson has noted the inevitable opening between joint and bursa when the supraspinatus tendon is torn.

How often this tearing happens, and how large a rôle it plays in our poor results, we do not yet know. It must be a serious factor, but there are no data as yet to help us in estimating its importance.

As to lesions of other bursæ, I know nothing, and am correspondingly skeptical.

* Boston Med. and Surg. Jour., May 31, 1906.

CHAPTER XIII

FRACTURES OF THE HUMERUS: UPPER END

FRACTURE OF THE HEAD

Here and there are reported fractures of the humeral head. These may accompany luxation, or may come independently; there may be a splitting of the head (see Fig. 196), or simply a chip split off the articular surface.

Either condition is very unusual. In either case there is a fragment

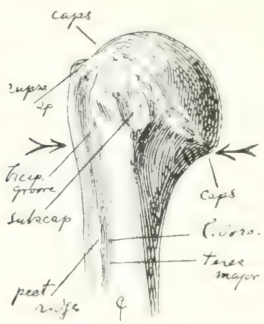


Fig. 194.—Head of humerus from the front.

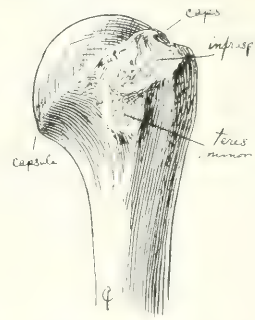


Fig. 195.—Head of humerus from behind.

that usually lies out of relation to the head, even after reduction of the luxation that may be present.

The fragment may unite to the humeral head in time, or may lie free. If it unites, it may increase the size of the head, and so limit its range of motion. If it does not so unite, we have, of course, an obstacle to motion, severe or trifling, according to its size and location.

The cases I have seen have been those in which the condition had been overlooked. These cases have shown poor results before open operation—good results or relatively good results after operation. As to the results of such fracture *properly reduced* with early motion and massage, I have no data.*

* In one case, seen with Dr. Horace Binney, there was a split running through the head and not breaking out until a point about 4 inches below. Union with some deformity was prompt. This represents a curiosity, not a type, I think.

FRACTURE OF THE ANATOMIC NECK

This much-written-of fracture is, *in fact*, rare.

It consists of a break between the articular head and the tuberosities, analogous to the fractures that occur close to the head of the femur. Like them, it is a fracture of the elderly. It may not be impacted, and

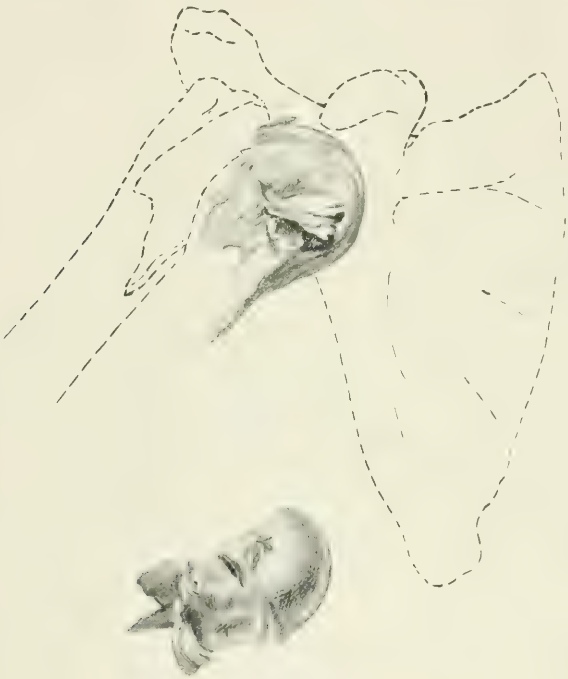


Fig. 196.—Splitting off of part of the head at the anatomic neck. The fragment pressed on the axillary vein, causing enormous edema of the arm, necessitating open operation. The fragment removed is shown above (two views); the relations are shown in dotted line. The fragment was removed, the remainder of the head shaped and held (in abduction) against the glenoid. The result was a useful arm, though with small power of abduction.

may or may not be strictly intracapsular. The anatomic neck lies within the capsule, but fractures do not often coincide with the limits of the neck exactly.

Since these cases have been studied with the x-ray it appears that real fractures of the anatomic neck are *very* rare. A few cases of fracture of the neck *with dislocation* are reported. (See Figs. 176, 178.)*

There are some few *uncomplicated* fractures at this point, mostly

* Since the above was written I have operated on a third case—clean fracture through the neck with the broken head lying under the coracoid process with the brachial plexus stretched across it.

impacted, in which the data gained through operation or otherwise are beyond dispute. There are some few museum specimens showing this fracture.

From the ordinary clinical point of view this break might almost be considered as a false conception, so rare is it. (What actually occur in this region are fractures separating the head, but running *through the tuberosities* or below the tuberosities.) I have personally seen twice an unimpacted fracture of the *anatomic* neck without luxation.

Where there is fracture of the anatomic neck without impaction, of course, there is a probability of non-union. It does not necessarily follow that a fragment loose in the joint undergoes necrosis.*

Fig. 197.—Impacted fracture of the anatomic neck of the humerus (x-ray, outlines added).

It simply does not unite and *may* be the cause of an irritative arthritis.

Any effort at repair is essentially on the side of the shaft, not of the head.

Diagnosis.—Some cases are recorded in which the displaced head has been felt, movable, with crepitus.

Crepitus alone may establish the diagnosis, if we can exclude fracture of clavicle or scapula, or a break of or through the tuberosities. Failing this, we must depend on disability, on local pain and tenderness, on the slight flattening of the shoulder, on the slight shortening of the arm, and on such information as the x-ray can give. Shortening is so slight, even if there is no impaction, that its measurement is hardly serviceable.

The impacted fractures are ofen doubtful, depending on x-rays that show change in the shape of the head without *definite* fracture lines.

Treatment.—*In the impacted cases* we need fixation only. A circular bandage or swathe, a shoulder-cap, and a sling will suffice (see Fig. 198) and need be kept on only two or three weeks before massage and motion

* Here, as elsewhere in intracapsular fractures, a factor somewhat neglected latterly undoubtedly plays a part, namely, the presence of synovial fluid. Blood does not coagulate normally within an intact joint, and without such coagulation efficient callus-formation is impossible. How far this fact determines the fate of intracapsular fractures is hard to say. I suspect it is quite as important as poor nutrition by vessels, etc.; certainly chips of bone bathed in synovial fluid do not die —and they do not unite.

are begun, and only a protective sling is needed. Fixation is ordinarily maintained far too long in these cases.

In unimpacted cases we must attempt to get the best possible position. This will be obtained, as a rule, by traction on the abducted arm, with pressure on the head if it is palpably displaced.

No *leverage* on the *head* is possible, as it carries no tendons and few, if any, shreds of ligament. It may be, and may remain, rotated, or it may not.

The reduction is almost a chance reduction at best.

Fixation is carried out in the way just noted. Probably in most such cases we shall not get union anyhow, so it is unwise to put off massage to wait for it too long. Unless there is reasonably prompt union, the indicated treatment would be excision of the fragment, leaving a clean false joint, as in excision.

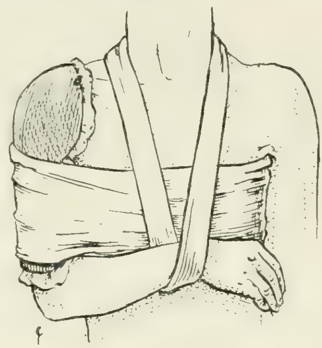


Fig. 198.—Circular swathe, felt shoulder-cap, and wrist-sling.

Such treatment would not be wise in a feeble, elderly person, especially if even tolerable function can be obtained in the case in hand, with the head still loose in the joint. Such operative treatment will be called for rarely in actual practice, for it is in such patients that such fractures oftenest occur.

Results.—Cases classed as of this type have typically shown excellent results in the *impacted* cases.

Of the unimpacted, all that can be said is that *mechanically* a false joint is tolerably good; the actual amount of function seems to depend inversely on the degree of associated arthritis excited. Results in operated cases are good, but normal power of *abduction* is not attained,* and the general range of motion is limited in some measure, as a rule.

FRACTURE OF GREATER AND LESSER TUBEROSITIES

These lesions not very uncommonly accompany luxations (see Fig. 166), but may occur alone.

The fracture of the *greater* tuberosity is not rare; that of the lesser is rare.

The presence of crepitus, the presence of a palpable, movable fragment, give the diagnosis of this fracture as a luxation complication. Sometimes the loose fragment may be felt. The treatment is that of the luxation, with protection carried on a little longer than would otherwise be necessary.†

* This is true of all shoulder excisions from whatever cause, and is a necessary result of the mechanics of the joint.

† For consideration of the tuberosity fracture as an *impediment* to reduction see under Shoulder Dislocations.

Like fractures may accompany fracture of the surgical neck. (See Fig. 214.) Here their presence may be diagnosed if we can feel the loose fragment; it may be *inferred*, from the apparent thickening or crepitus on palpation, but the skiagraph is apt to be needed to make sure.

Fig. 199.—Fracture of the greater tuberosity and of the neck (case seen with Dr. W. E. Fay; *x*-ray by Dr. Percy Brown).

Greater Tuberosity

Where either tuberosity alone is broken, without luxation, we are apt to find muscle action as the cause; the result is an *avulsion* of the tuberosity; the displacement is not apt to be great, as some connection of the fragment with its bed usually persists.

Fracture of the *greater tuberosity* may, of course, occur from *direct* violence.

Displacement of the greater tuberosity is apt to be upward, with some forward or backward displacement, and with an (inconstant) rotation of the fragment.

Diagnosis.—The head rotates with the shaft. There is no shortening. There is no flattening of the shoulder. There is thickening (bony) of the region involved. There may be a palpable loose fragment. Manipulation may give crepitus. In addition to the usual local tenderness and disability there is pain on attempts at voluntary outward rotation. The arm may tend to rotate inward.

Treatment.—Treatment consists of fixation pure and simple, on the lines above described (under Anatomic Neck Fracture). It is sometimes well to treat the lesion with the arm on an abduction splint in case of marked upward and outward rotation of the fragment of the tuberosity. (See Figs. 234 and 235.*) In cases where this fracture complicates luxation, it may cause some trouble in reduction because it remains attached to the glenoid rim and may get in the way. In other cases the fibrous attachments to the humerus are preserved, and reduction is a simple matter.

Union is usually bony. Necessarily, there is some thickening and deformity. If extreme, this thickening may limit motion by contact with the acromion. It does not affect the use of the muscles inserted on the tuberosity, as a rule.

Lesser Tuberosity

This process is still less often torn away, with or without luxation. The lesser tuberosity displaces *inward* when it gives way. When it is

* If this does not give proper reduction, open operation will be indicated.

broken, there is no longer an inner edge to the bicipital groove, and the tendon may slip inward.

Diagnosis of the fracture as such depends on local tenderness and on the presence, to the inner side of the humeral head, of a hard, movable mass not sharing in rotation movements. Inward rotation by active muscle action is lost. Attempts at such action give pain. According to Bardenheuer, the arm tends to lie in *outward* rotation.

Treatment is by fixation with the arm flexed and adducted, to relax the biceps and the muscles directly attached to the tuberosity, with a shoulder-cap added for protection.

Results.—Functional results would seem to be uniformly good, though not perfect. There is apt to be some persistent thickening, owing to the necessarily imperfect replacement of the fragment.

SEPARATION OF THE EPIPHYSIS

The shape and limits of the epiphysis are shown in Figs. 200, 201, 202, 204.

Fig. 200. — Epiphyses of humerus at eight years (Warren Museum, specimen 334).

It may be separated at any time in childhood, beginning with the separations inflicted by the obstetrician in arm traction, but separation is rarely met except between four and thirteen years of age. During this period it is far commoner than luxation—probably much commoner than fracture of the surgical neck. It results apparently from the same sorts of trauma.

The lesion is a clean separation in the earlier years; later there is apt to be a chip of the diaphysis separated with the epiphysis. There is the usual tendency to extreme stripping up of untorn periosteum that occurs in most epiphyseal separations. Here this stripping occurs on the outer side, as a rule. (See Fig. 202.) Displacement, usually of the shaft forward and inward, is often great. Damage to nerves or vessels is rather rare.

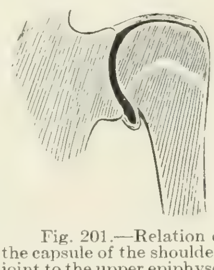


Fig. 201.—Relation of the capsule of the shoulder-joint to the upper epiphyses of the humerus (diagram).

Diagnosis.—In childhood this is the first lesion to be thought of in this region. The presence of some grave damage is ordinarily obvious from swelling and disability. On palpation, the characteristic displacement is made out and the upper end of the shaft is easily felt, displaced up and inward. Sometimes it

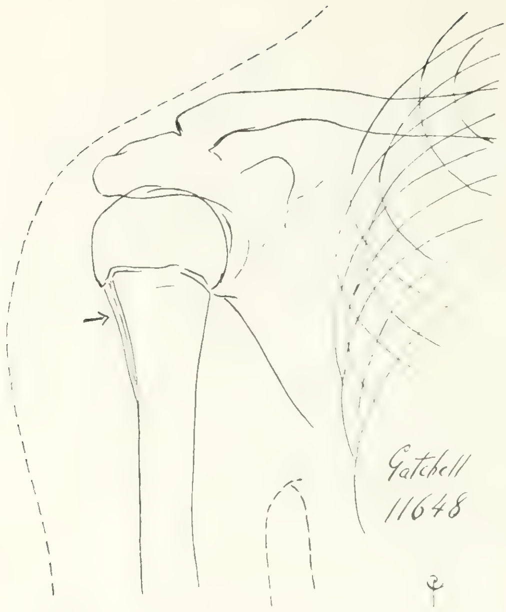


Fig. 202.—Shows very clearly the stripping of periosteum (still attached to the epiphysis) from the shaft. Tracing of an x-ray taken after reduction.

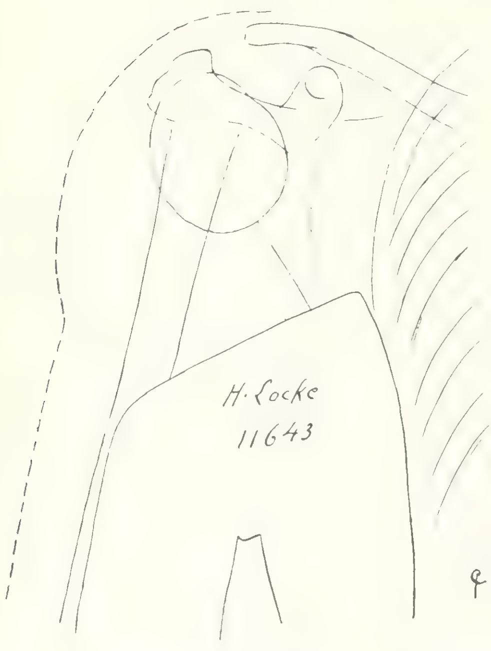


Fig. 203.—Separation of the epiphysis: epiphysis rotated, shaft displaced up, forward, and a little outward (author's case).

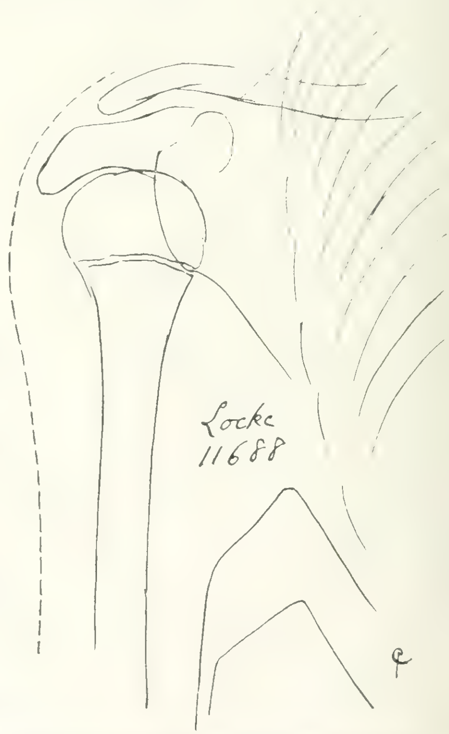


Fig. 204.—The same case after open reduction.

gives an actually *visible* projection. (See Figs. 205 and 207.) There is some shortening—but not necessarily a great deal of shortening.

The axis of the arm is obviously displaced, just as with luxation, up, inward, and forward. The anterior axillary fold is distorted (Fig. 223).

The head is palpable only as the normal resistance to be felt under the acromion.

There may be crepitus, but only *soft* crepitus, often to be brought out only by vigorous manipulation under traction, for the shaft is apt to slip clear by the head.

The injury is a perfectly typical one; the deformity is almost always the same, the displacement varying only in degree.* The shaft is pulled inward and upward by the muscles, even if not originally so displaced. The head lies in the socket, but may rotate as it does in the fracture of the surgical neck. (See Fig. 203.)

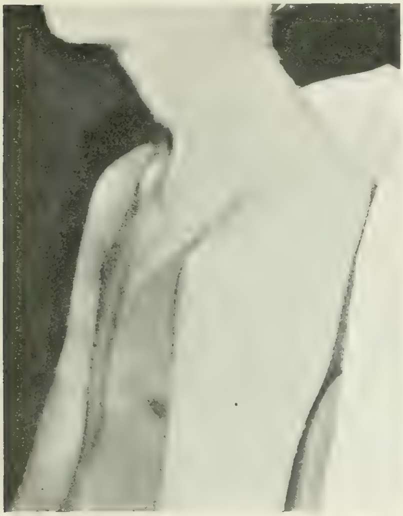


Fig. 205.—Separation of the epiphysis, shaft displaced up and forward. On operating I found the end of the shaft buried in the deltoid muscle. Reduction was easy. Position was maintained with a single suture of kangaroo tendon placed through drill-holes. An ideal result was obtained.

Fig. 206.—*X*-ray print (outlines sketched in) of the case shown in Fig. 205. Note how little the deformity shows for in the front view.

Treatment.—The problem of treatment is no different from that of a fracture across the tuberosities, except that—and this is important—we have in these epiphyseal cases a long strip of intact tough periosteum. This seems to act as an obstacle† to the ordinary means of reduction.

* Original backward or outward displacement I have seen but twice.

† Allis has shown how such a periosteal strip may be a real obstacle in the reduction of thigh fractures; probably it acts in a like manner here, though the humerus head shows no great deviation from the line of the shaft. In the main, however, the obstacle here is that the strap of periosteum is short, and a pull in the line of the shaft tends, not to reduce, but to drive the displaced fragments together. (See Fig. 210.)

Certainly the average end-result of a separation of the epiphysis is far less satisfactory than that of a fracture at like height in the adult, so

Fig. 207.—Separation of the epiphysis with moderate displacement up and forward. This represents the best result obtainable by reduction and splints in this case (*cf.* *x*-rays, Figs. 208 and 209). Such a result gives little permanent deformity and good function, but is far from ideal.

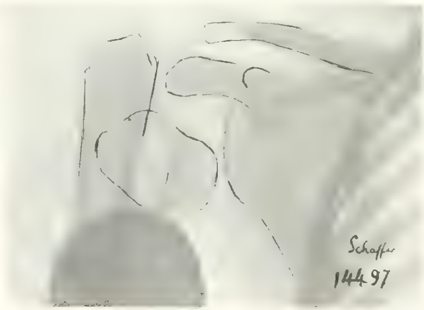


Fig. 208.—*X*-ray of case shown in Fig. 207. This *x*-ray shows the original displacement. (Lines reinforced.)

far as position goes. I have seen case after case with a deformity like that of Fig. 207 or even Fig. 205, after treatment by surgeons of

acknowledged skill and carefulness, and in my own cases the results have not been what I might wish.

Accordingly, my belief as to the desirable routine is as follows—we should attempt reduction by abduction, traction, direct pressure, etc., as for fracture. If apparently successful, we should "check" our replacement by palpation and by fresh Roentgen plates.

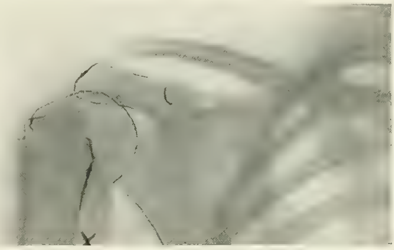


Fig. 209.—*X*-ray of the same case after reduction. This plate shows a spur of the shaft (on the inner side) torn away with the epiphysis—a not unusual complication.

If the replacement is *not good*, we should cut down and reduce the displacement under the eye; then suture the bones with kangaroo tendon or with a reliable catgut to insure maintenance of reduction. In this way we can secure *perfect* reduction and results.

This operative procedure has frequently been carried out with good results by myself and others. I have operated in four cases after repeated attempts by myself and others to reduce displacement by ordinary methods. The obstacle in one case chanced to be not periosteum, but an embedding of the end of the shaft in the substance of the deltoid. Reduction was made and secured by a stitch of kangaroo tendon. Convalescence was uneventful, and a *perfect* functional result was secured in a very short time. (See Figs. 205 and 206.)

Fig. 210.—Sketch to show the periosteal obstacle to reduction. A pull in the direction of the arrow tends to jam the fracture, not to reduce it.

The fact that I have not operated oftener is due purely to the conservatism of my patients and of the average surgical opinion of this community. I believe this to be an operable lesion in the *majority* of cases.

Results.—Cases *perfectly* reduced get *perfect* functional results. Cases ill-reduced get surprisingly good function, but retain, as a rule, a limitation of forward elevation and of abduction, owing to the deformity and thickening, and show, for years at least, an obvious deformity. Later interference with growth in the length of the arm is recorded in a number of cases, but seems so rare compared with the total number that we may almost disregard it.

FRACTURE THROUGH OR BELOW THE TUBEROSITIES (Including "Surgical Neck" Fractures)

The usual fracture lines are shown in Figs. 211 and 212. Solid impaction may occur, or a light impaction, or oftenest none at all. In the last case the deformity may be considerable.

Fig. 211.—Fracture of the "surgical neck," unimpacted. The sketch to the left above, shows the fracture line visible in the original plate.

Fig. 212.—Fracture of the surgical neck, below the epiphyseal line. The sketch shows details visible in the plate, not in the print.

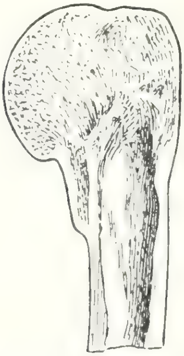


Fig. 213.—Impacted fracture of the surgical neck and tuberosities in section (Warren Museum specimen 8539).

Fig. 214.—Fracture of surgical neck of humerus, with splitting away of the greater tuberosity Case seen with Dr. E. G. Brackett.

The injury results from a fall, usually on the outer side or on the front of the shoulder, from abduction (leverage across acromion?), from a force applied to the elbow driving the bone up and forward, or even from a fall on the back of the shoulder.

Lesions.—Apart from the vary-

Fig. 215.—Fracture of the surgical neck; shaft displaced up and inward.

Fig. 216.—Impacted fracture of the surgical neck (sketch from x-ray plate).

ing height of the fracture lines, there is a good deal of variation in extent and direction of displacement, and of reciprocal impaction if any impaction exists.

There is no use in classifying these displacements too closely, for we do not yet know what they correspond to in cause, in indicated treatment, or in prognosis. Figs. 211 to 222 will suffice to show the variants of type. The eroded forms

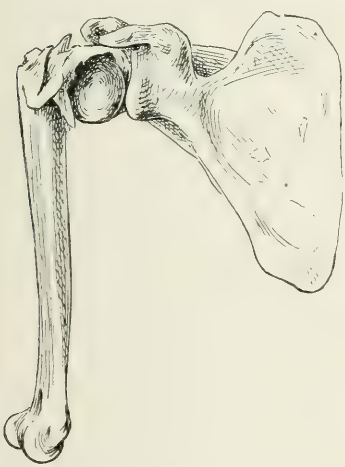


Fig. 217.—Fracture of the surgical neck of the humerus. Much displacement. Loose fibrous union only (Warren Museum, specimen 991).

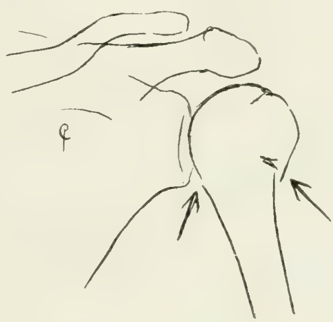


Fig. 218.—Surgical neck fracture impacted in slight abduction, though to a less degree than Fig. 216 (sketch from plate).

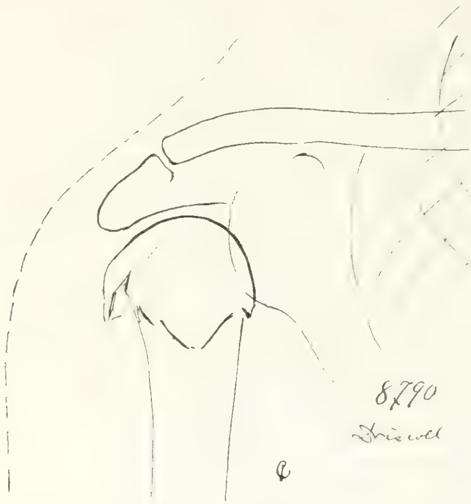


Fig. 219.—Impacted fracture of humerus, fracture line running through the tuberosities (tracing from x-ray plate).

(Fig. 217) seen long after injury leave us with little information as to the original plane of lesion.

Associated fracture of one or both tuberosities is not rare. (See Figs. 166 and 199.) Spiral or oblique lines are not very uncommon.

It may be noted that in all the cases that one would think of putting

Fig. 220.—Fracture of the surgical neck, unimpacted (outlines added to poor x-ray print).

Fig. 221.—Fracture of the surgical neck, just below the epiphyseal line, in a child. The pointers show the level of the epiphyseal line.

in this class the lower fragment carries the attachment of the great adductors (the latissimus and pectoral), while the head carries the in-

Fig. 222.—Case operated by the writer August 20, 1903. Smashing of the surgical neck, complicated by glenoid fracture (rough sketch from an inadequate x-ray).

Fig. 223.—Fracture of the surgical neck: displacement of the shaft up and in (shifting of the anterior axillary fold); loss of radial pulse.

Operation showed thrombosis of the brachial artery, with tearing of all coats save the adventitia. The clot was cleared out, and arterial suture (end-to-end) was done; circulation in the brachial artery returned.

Evidently clotting had occurred lower down. The radial pulse did not return, but collateral circulation was established after two days, and the final result was excellent.

sertions of the short rotators, and, what is more important, of the short abductors.

It is for this reason that, in cases in which there is no impaction, the *tendency to displacement is practically constant,* namely, abduction and some outward rotation of the upper fragment, adduction—and usually forward and upward displacement—of the end of the shaft.

Fig. 224. — Fracture of neck of humerus. 1, Head of bone, rotated and a little displaced downward; 2, tuberosities displaced far up beyond the head; 3, new-formed periosteal bone (courtesy of L. R. G. Crandon).

There is usually an obvious shifting of the anterior axillary fold (Fig. 223).

This fracture is not very liable to interposition of periosteum or muscles or tendons between the fragments.

Nerve or vessel injuries are rather rare.

Diagnosis.—*Impacted.*—The signs of localized damage are obvious. Ecchymosis and swelling are usual. Tenderness, voluntary fixation due to pain, pain about the joint and down the arm, are nearly always present.

The arm lies at the side, not abducted, but the general axis may be displaced inward, giving an appearance not unlike that of the displacement with luxation.

The arm is held supported by the other hand.

Motion is limited only as a result of pain and spasm, as a rule.

There is flattening of the shoulder from the outside, slight prominence of the shoulder in front.

Shortening is slight, often apparently absent.

Unimpacted.—If the fracture is loose, there is usually little flattening on the outside, but an obvious prominence of the upper end of the *shaft* in front—a *rough* prominence very different from the smooth head of a luxation, and usually lying a bit lower down.

There is shortening, varying from almost nothing to an inch or more.

Failure of the head to move with the shaft, to rotate when the elbow is rotated, is the best single sign; it is of no use unless the fracture is loose; moreover, we must be careful not to loosen an impacted or firmly entangled fracture to test this point.

Fig. 225.—Line of measurement for shortening. Acromial spur to external condyle.

Crepitus is often obtainable in loose (or loosened) fractures, but not always easily obtainable.

Pain on upward pressure on the elbow, pain felt at the shoulder, is of some value as an indication of fracture.

Treatment.—*Impacted.*—In case there is impaction, our first duty is to determine whether we should not leave this impaction alone. As a rule, we should leave it alone. It is justifiable to break up an impaction here only if the position is bad enough to justify us in taking a definite, even if small, risk of non-union. Often it is wise not to decide until a skiagraph is taken. If we break up the impaction, the further treatment is that of any unimpacted case.

If we decide to let the impaction remain, our treatment is one of fixation and protection only—sling, circular, and shoulder-cap. This must be retained for about four weeks, but massage may be begun at one week, and passive motion, gently, as soon as two weeks at latest.

Unimpacted Fracture. Reduction.—Here we have to deal with a head sometimes displaced forward or back, almost always rotated up- and outward by the supraspinatus and infraspinatus and teres minor muscles, and pretty firmly fixed. The shaft, adducted, usually lies to the inner side, either overlapping the head or entangled with it at an angle.

In either case we must use traction with direct manipulation of the end of the shaft. If we abduct the arm and rotate it a little outward, it will better correspond to the position of the head, and reduction will go better.

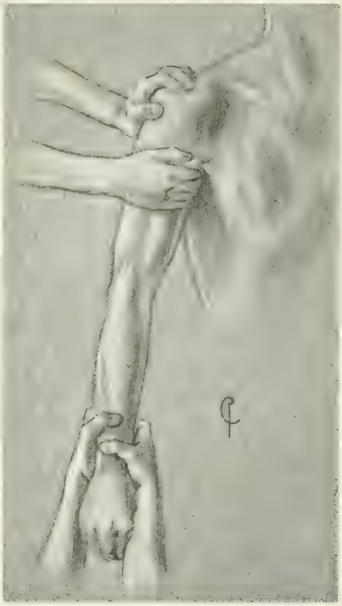


Fig. 226.—Reduction; traction in the line of the arm; a direct *outward pull* on the shaft with one hand, while the other shoves the shoulder *inward*.

Abduct, then, apply strong traction in the line of the arm, rocking and rotating it the while, and have an assistant press on the displaced upper end of the shaft, pushing it toward the head, which is supported by counterpressure (Fig. 226).

The success of reduction is indicated by crepitus, and in fortunate cases rewarded by an interlocking of fragments. The perfection of position is tested by palpation, by measurement of length, and by the fact of rotation of the interlocked upper fragment with the arm.

Sometimes traction downward, or downward and backward, is more efficient. It is all a matter of the detail of displacement.

Often a leverage over the fist or wrist as a fulcrum on the inner side of the displaced lower fragment helps reduction.

Apparatus.—I have always found a carefully fitted axillary pad, co-

Fig. 227.—Grip for traction combined with *outward* rotation.

Fig. 228. Traction combined with *inward* rotation; rarely used or needed.

aptation splints, closely applied, running up the outer, front, and back sides of the upper arm, a wrist-sling, a wide swathe, and a shoulder-cap

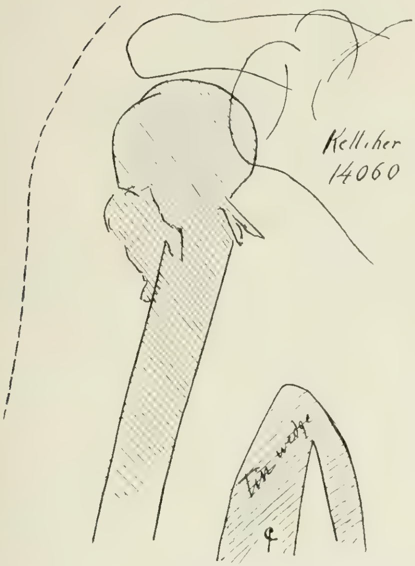


Fig. 229.—Axillary pad applied too low. Direct tracing from x-ray plate. (Author's case).

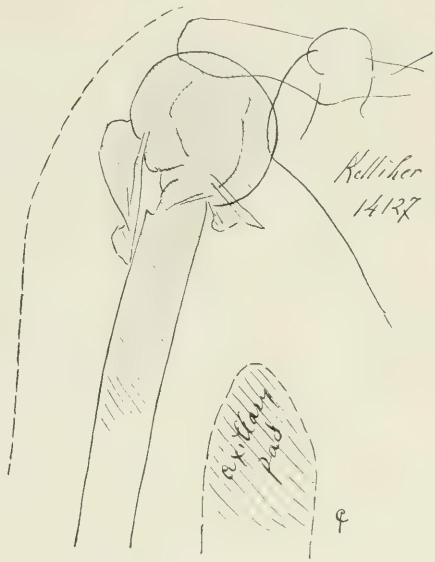


Fig. 230.—Same case as Fig. 229. Axillary pad applied at the proper level; note the improved position.

over all for protection, to be a perfectly satisfactory apparatus. An elbow splint is rarely indicated. As a rule, sufficiently good entanglement, if we may so call it, of the broken ends can be secured so as to make the tendency to displacement by the pull of the deltoid comparatively slight; all the other muscle pulls may be neutralized in the above apparatus by arranging padding.

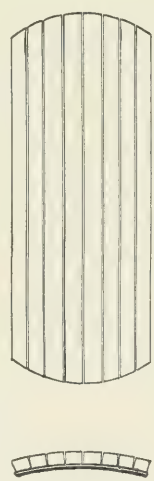


Fig. 231.—Coaptation splint seen flat and in section. Made by laying thin wood on adhesive plaster and splitting the wood with a knife.

Many forms of dressing have been recommended. One class rest on the theory of necessary traction in the line of the arm. These are: a weight hung from the elbow by adhesive-plaster strips applied above the elbow,* the patient being up and about, or Bardenhauer's complicated pulley apparatus for traction in bed, and, finally,—best of all, if we want light traction,—a plaster-of-Paris bandage that both fixes the arm and weights it, while the arm is supported only by a sling at the wrist.

If we have a spiral or oblique fracture, or if we must work against spastic action of very powerful muscles, one or another of these methods may be of

* An internal angular tin splint may be applied, and the weight hung from this. (See Fig. 233.) This is efficient and comfortable.

use; ordinarily, they are not needed, and we had better get good reposition first—it is not so hard to hold it once it is attained.

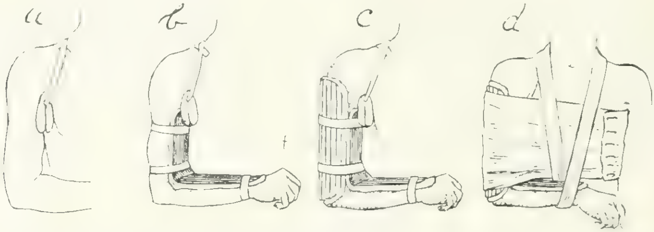


Fig. 232.—*a*, Application of axillary pad, fastened with an adhesive band. *b*, "Internal angular" splint, padded and strapped on with adhesive. *c*, Coaptation splints strapped on. *d*, Wrist-sling and circular swathe.

Another class of devices is intended to keep the arm in abduction to correspond with the displacement of the upper fragment. Mitteldorpp's triangle is the most used type. It may be dismissed with the remark that it keeps the arm abducted, but abducted in internal rotation. The Osgood and Penhallow splint (see Figs. 322 and 323) I have used and found better in this regard, but even this is not usually adapted to this particular fracture.

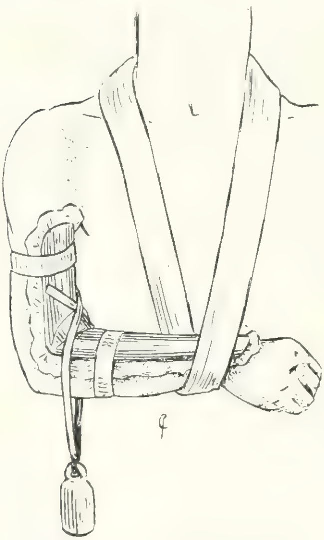


Fig. 233.—Wrist-sling, "internal angular" splint. Traction by a weight hung on this splint by means of adhesive plaster. This method is efficient only when the patient is up and about.

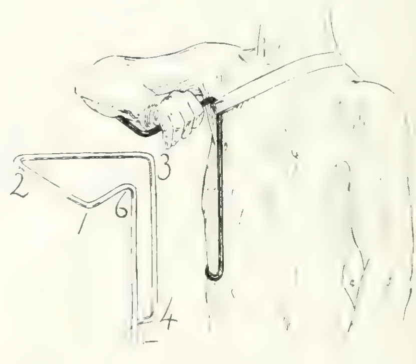


Fig. 234.—Modified form of Dr. Geo. H. Monk's "Triangle," made of $\frac{1}{4}$-inch iron wire. 1–2 runs along and under the forearm; 2–3, from elbow to scapula; 1–6 gives the hand-grip, 3–4–5–6 gives the support against the body. The wire is adequately padded; the space between 1 and 2 and 2 and 3 is bridged with cloth to hold the arm. The splint is slung from points 6 and 3 around the opposite side of the neck. It is efficient and comfortable. A larger space, 1–2–3, may be allowed to let the arm lie clear of the wire.

If *abduction* is necessary,—that is, if on reduction in abduction we

cannot so entangle the fracture surfaces that the head rotates down when the arm is lowered,—then the triangle devised by Dr. George H. Monks* will serve best (this is shown in Fig. 234). When such a splint cannot be made readily, the same position may be secured with plaster-of-Paris (Fig. 235).

Reduction—and reimpaction so far as possible—is the keynote of success; this once accomplished, special apparatus is not often called for.

After-treatment.—Apparatus must be worn for three to five weeks, according to the promptness of apparent union (tested by elevation, abduction, and rotation). Early massage and passive motion at two

Fig. 235.—Plaster-of-Paris "cast" to insure fixation of the shoulder in *ab*duction. This cast was used for an operative case: over the shoulder a window was cut out for wound inspection. Plaster is much less comfortable than the triangle of Fig. 234.

or three weeks help much. Hand, wrist, and elbow motions (passive) are indicated within a week.

Results.—Union usually occurs promptly. Permanent non-union does occur, but is a rarity.

Delayed union is less rare, but not to be expected.

There seems to be no tendency to progressive deformity.

Return of function is slow; as with luxations, the ability to put the arm behind the head and behind the back returns last of all, but unless the reposition has been unfortunate it does return.

Do not expect *end-results* before four to six months, and adapt the prognosis to something near this date.

* Monks, Boston Med. and Surg. Jour., 1890, cxxiii, p. 183.

CHAPTER XIV

THE ELBOW

Injuries to this joint are very common, especially in children under twelve years of age. In children, falls are apt to be received on the elbow, because children do not save themselves by throwing out their hands. So it happens that elbow injuries in adults result, as a rule, from *severe* accidents, while in children the fall that gives such injuries may often enough be very slight. From this fact, and from the anatomic differences dependent on the very complicated form of epiphysis at the

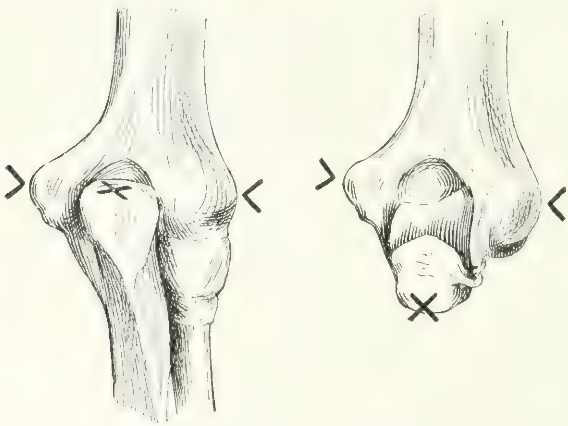


Fig. 236.—The relations of the three bony points at the elbow in extension and in flexion (from behind). The marks are placed upon the internal and external condyles and olecranon process (diagram).

lower end of the humerus, the fracture forms in adults and those in children are very unlike. The luxations are, of course, practically identical.

LANDMARKS

The landmarks of the elbow are the olecranon, the two condyles, the head of the radius, and the lower portion of the shaft of the humerus at the front.

It is often stated that the two condyles are equally distant from the olecranon, that they lie at the same height when the arm hangs at the

side, and that, with the arm at right angles, the olecranon and condyles are on the same vertical plane.

As a matter of fact, the olecranon is distinctly nearer to the internal

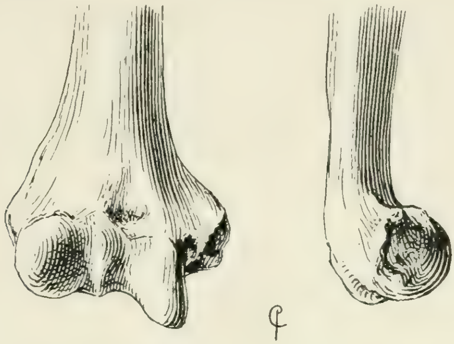


Fig 237.—Normal humerus (lower end) from in front and from outer side.

than to the external condyle, and in some individuals this difference is considerable (Fig. 236).

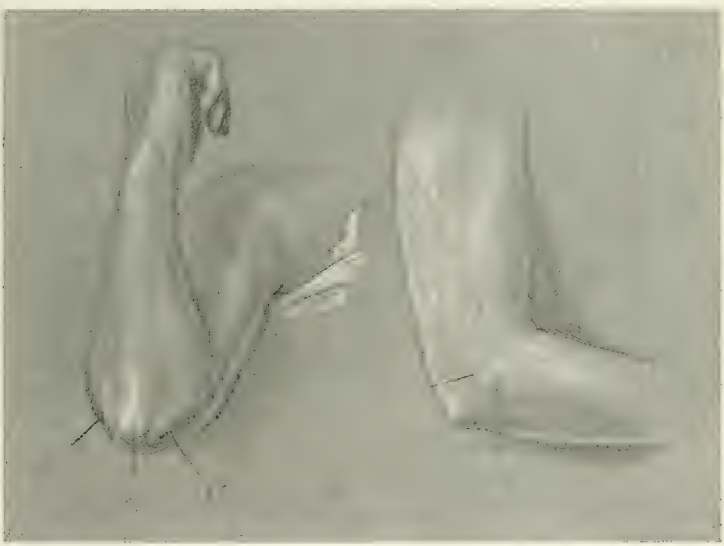


Fig. 238.—Landmark-drawings from the model: 1, 3, External condyle; 2, head of radius; 4, olecranon; 5, internal epicondyle

With the arm hanging straight, the olecranon is apt to lie a trifle *higher* than the line between the two condyles.

In the lateral view, with the arm at a right angle, the olecranon

tip, as is seen in the accompanying cut (Fig. 240), lies distinctly *behind* the plane of the condyles.

In determining the landmarks of an injured elbow not only must these facts be borne in mind, but a comparison must be made with the elbow on the sound side, for normal variations are considerable. In feeling for the landmarks, the elbow is flexed.

Fig. 239.—Shows the increase in prominence of the olecranon on increase of flexion (from the model).

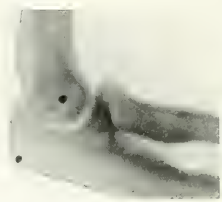


Fig. 240.—The olecranon lies *behind* the condyles. The dots show the prominent, easily felt points of external condyle and olecranon respectively.

The olecranon is first identified, if possible, by its continuity with the subcutaneous surface of the ulna.

Shortening is measured from the olecranon. (See Fig. 242.)

By pressing in above the olecranon behind, it is often possible to feel the sigmoid surface of the ulna, if there is dislocation (Fig. 241).

Fig. 241.—Palpation of the sigmoid cavity (in backward luxation).

The internal epicondyle may be felt in most cases without difficulty, and may be recognized by its hook-like shape and by the presence of the ulnar nerve within the groove formed by this hook (Fig. 243).

In many instances the ulnar nerve is *more certainly* to be identified than any other structure about the elbow, being the only structure on the inner side, running vertically, which can be rolled under the finger.*

The external condyle can best be identified

Fig. 242.—Measurement of shortening of arm, from acromial spur (see also Figs. 137 and 225) to the tip of the olecranon. The elbow must be held at a right angle.

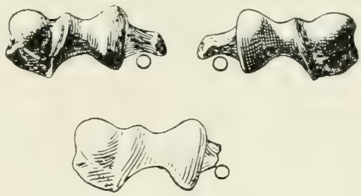


Fig. 243.—Relations of ulnar nerve at the elbow. Right and left humerus from below. Normally, the nerve lies behind the internal epicondyle. If this process is broken, the nerve lies exposed, as shown in the lower figure.

by placing the first two fingers on the external condyle and on the radial head respectively, and rotating the forearm (Fig. 244).

Any point which rotates *freely* is presumably the head of the radius.

There is normally a sufficient asym-

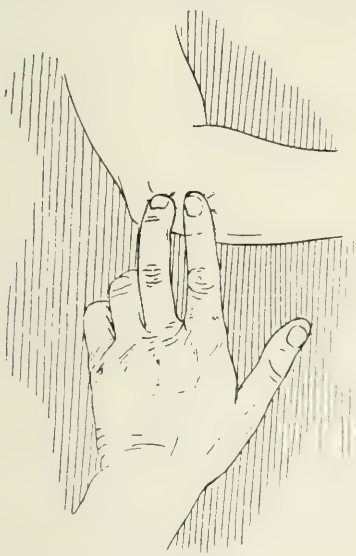


Fig. 244.—Palpation of the external condyle. One finger rests on the condyle, one on the radial head in front of it; when the forearm is rotated, the two are readily differentiated.

Fig. 245.—Palpation of external condyle just above the radial articulation to identify and to test mobility.

metry of the radial head so that this rotation is readily perceived, even though there be some swelling.

* "The Ulnar Nerve as a Landmark of the Elbow," F. J. Cotton, Boston Med. and Surg. Jour., 1906, clv, p. 37.

Any *fixed* point (felt in this test) is probably the external condyle.

Except for this test by rotation there is likely to be considerable confusion in this matter, as the radial head may frequently be the most prominent structure at this side of the joint.

Flexion and extension at the elbow in most cases help the distinction, for the condyle does not move much with the forearm, even if there is a break above it.

The position of the lower part of the humerus in front is best made out by pushing the thumb in behind the biceps on the outer side, as shown in the sketch (Fig. 246).

In determining all these landmarks in a swollen elbow it may be necessary to reduce the edema by massage.

In this massage the tips of the thumbs and fingers are used, first to press in slowly until a considerable pit is produced; then this pit is, by kneading in a divergent spiral, enlarged to the size that is needed to bring the given landmark within reach of the finger-tip. For any fracture or luxation within a week or ten days from the date of injury this method is perfectly efficient, and, if carried out slowly, it is practically painless. Sometimes temporary firm bandaging of the part with a rubber bandage or with an elastic woven bandage is a useful preliminary to this examination.

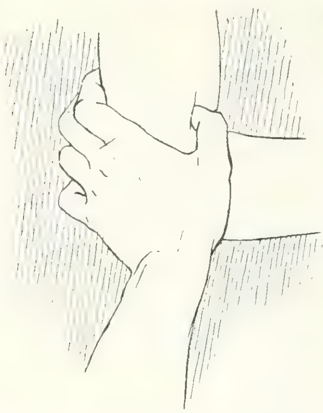


Fig. 246.—Palpation of the front surface of the humerus close to the joint.

Fig. 247.—Synovitis of the elbow-joint. The swelling lies on either side of the joint, bisected, so to speak, at the back by the depression made by the tight triceps tendon. The swelling is made more obvious by flexing the joint.

Later, there occurs in many fractures a firm infiltration of the subcutaneous and deeper tissues, especially just outside the area covered by splints, that *cannot* be massaged away satisfactorily.

Elbow Dislocation

Dislocations at the elbow are common in both children and adults. They do occur from falls on the elbow, but seem to come more often from falls on the hand so received that the arm is driven into hyperextension, or is driven forcibly up in a position of partial extension. (See Fig. 248.)

Fig. 248.—Mechanism of luxation backward. Either the bones of the forearm are *driven backward* (elbow flexed) or they are *thrown out by leverage* (elbow hyperextended).

LESIONS

Obviously, there must be much tearing of ligaments in all forms of elbow luxation.

Backward Luxation.—In the usual backward luxation the internal lateral ligament is always torn; the external lateral is usually torn. The anterior ligaments and capsule are, and must be, ruptured; behind, the damage is sometimes only a ligament tear, but often it is, in the main, a stripping up of the periosteum* from the shaft of the humerus.

Either epicondyle may be torn loose: the internal is often torn off by the strain on the internal lateral ligament. If torn loose, these condylar fragments are displaced *with the forearm*, usually backward.

COMPLICATIONS

In rotatory luxation, particularly, the displaced internal epicondyle may, on reduction, be driven *into* the joint.

There may be damage to radius or ulna at the joint.

There may rarely be an entanglement of the *biceps tendon behind* the external condyle (Michaux, autopsy); other than this, there seem to be no tendon or muscle complications worth considering.

Tearing of the *brachial artery* belongs to the complications of the rare compound luxation, and is excessively rare at that. (Flaubert's case of brachial artery rupture resulted not from the dislocation, but from the reduction manœuvers.)

Nerve complications, save contusion or pinching of the ulnar, are also practically confined to cases of compound dislocation. Median and musculospiral lesions have occurred.

Ulnar nerve injury, on the other hand, is not rare. The ulnar nerve is rather firmly bound down in the groove behind the internal epicondyle, and it *may* be hurt in any kind of luxation, and is *apt* to be

* This stripped-up periosteum is the source of the massive formation of new bone behind and to the outer side of the joint, regularly found at operation on old luxations.

hurt if there is a tearing off of this epicondyle. Two cases in point have lately come under my notice: in one the nerve was stretched *over* the displaced epicondyle; in the other, the epicondyle, dragged *into the joint* in reduction, compressed the nerve by holding taut a strip of fibrous tissue that crossed the nerve.

In other cases the mechanism is one of mere contusion at the time of displacement or of a temporary stretching, fully relieved by reduction.

In a good many cases of dislocation the patients complain of *temporary* pain or numbness in the ulnar side of the hand.

Compound luxations are rare.

If there is penetration of the skin, it is due to the protrusion of the humerus through the soft parts *in front* of the joint.

GENERAL DIAGNOSIS OF LUXATIONS OF THE ELBOW

According to the direction of the force, and more particularly according to the damage done to the ligaments, the direction of displacement varies. Most often it is directly backward; not unusually more or less outward as well.

Rotatory luxations also occur—*i. e.*, luxations backward in which but *one* lateral ligament is torn and in which there is total luxation of *one* bone, partial luxation of the other.

Inward luxation, and the *forward* displacement, though among the well-attested possibilities, are so rare as to be only curiosities.

"*Divergent* luxations" are still rarer.

There is in the backward luxation at this joint, as in other dislocations, a good deal of pain. Swelling is not always especially prompt or very severe.

In the backward luxations the arm is held in semiflexion (at about 130 to 140 degrees, usually); flexion is painful, and is practicable only to perhaps 110 degrees. Extension is possible to a varying extent, but is never normal. All motion is painful. There is marked muscle spasm.

On inspection the displacement is obvious to the practised eye. The only question is usually between the dislocation and the supracondylar fracture which results from like mechanical causes, and shows a similar displacement.

In dislocation (backward) the olecranon lies behind the humerus, *behind its normal relation;* there is a concavity above it, equally perceptible whether it appears as *a*, in Fig. 249, or as *b*.

The prominence of the olecranon is increased by flexion of the arm (Fig. 239).

On examination we first identify the various landmarks—the two epicondyles, the olecranon, and the radial head. At times it may be necessary to massage away the edema, but this is always practicable with patience, except in old cases.

As a rule, it is possible to feel the hollow of the olecranon at the back of the elbow, as indicated in the sketch. If this is clearly felt, the question of diagnosis is settled.

The head of the radius may be certainly identified by laying two fingers, one on the external condyle, the other on the radial head (see Fig. 244), and then rotating the forearm.

The internal epicondyle is recognized by its hook-like shape, and, if there is any doubt, by its relation to the readily palpable ulnar nerve.

As to the external condyle, there may be some question, especially if the dislocation be out and back or rotatory; with direct luxation backward there is no trouble. If the dislocation be directly outward, of course, the external condyle will be beyond reach of palpation. If it is within reach, it may be distinguished from the radial head, which usually lies in contact with it, by the rotation of the radius, and by the fact that the condyle does not move with the radius in flexion and extension. Remember, however, that a *fractured* external condyle may so move, though very slightly.

With the five landmarks—olecranon, head of radius, internal epicondyle, external condyle, front of lower end of humeral shaft—all determined, there need be no doubt as to the question of displacement in any of the forms of luxation, and but rarely in the fractures.

Whether in the presence of a dislocation there are or are not associated fractures is not so easily determined.

Avulsion of the tip of the *internal* condyle very often complicates dislocation, and not very infrequently small portions of the *external* condyle are loosened, with the periosteum.

Fractures of the *coronoid* complicating dislocation are less heard of since the x-ray has given more accurate data. The writer has seen but one case, though he has tested a number of cases with the x-ray in which this diagnosis *preceded* the skiagraph. Fractures of the radial neck or head are rather rare complications.

Cases in which dislocation seems to be complicated with fracture of the *external condyle* as a whole often prove to be backward and outward dislocations uncomplicated—at least this has proved to be so in the writer's cases. As a rule, it seems safe to generalize that the chances are heavily in favor of a dislocation being uncomplicated, unless the internal epicondyle is torn away.

The common mistake is not the overlooking of these fracture complications, but that of diagnosing dislocation when, in fact, there is only a fracture, entirely *above* the joint.

LUXATION BACKWARD

Such luxations are very common and form the overwhelming majority of elbow dislocations. They occur both in adults and in children.

The general appearance is obvious from the illustrations (Figs. 249, 250, etc.). Swelling and pain vary greatly. If there is little swelling, the diagnosis is often made almost on sight. The diagnostic points have been gone over under general diagnosis and hardly need more discussion. Careful identification of landmarks—very easy unless there

a *b*

Fig. 249.—Luxation backward may give, in case there is no swelling, the diagnostic outline seen at the left (*a*); the sketch on the right (*b*) is the usual picture, with swelling, less readily diagnosed.

is swelling—gives positive diagnosis. Complicating fractures are rare, and are usually diagnosed only during or after reduction.

Reduction.—The overwhelming majority of dislocations are backward, or back and slightly outward. They are usually easily reduced.

There are several methods. The writer has almost always used

Fig. 250.—Sketched from Cooper's plate. A dissection of a backward dislocation at the elbow: *A*, Humerus; *B*, olecranon; *C*, radius; *D*, ulnar shaft; *E*, internal condyle, trochlear portion; *F*, coronoid process; *G*, inner surface of capsule; *H*, brachialis anticus; *I*, biceps tendon; *J*, triceps; *K*, brachialis; *L*, biceps muscle.

one—moderate extension downward, traction on the forearm, with counterextension on the upper arm, then a sweeping motion down and into flexion, with some attempt at separation of the joint surfaces as flexion is begun (Fig. 263). This has never failed to work in recent cases.

Fig. 251.—Fresh luxation backward (outlines added to x-ray print).

Fig. 252.—Backward luxation, over a fortnight old.

Fig. 253.—Old unreduced backward luxation of left elbow, girl of eleven years.

Another method, gentler and equally effective with the readily reducible dislocations in children, is as shown in Fig. 262.

Here the weight of the arm gives most of the forward traction.

Fig. 254.—Backward dislocation, twenty-four hours old. Readily reduced under ether (plate poor, freely retouched).

Fig. 255.—*X*-ray; same case as Fig. 253.

The thumbs shove the olecranon down and forward, while the fingers steady the arm and give counterpressure.

A method much described and a good deal used is direct traction with hyperextension. (See Fig. 264.) This seems based on the theory that the tip of the coronoid process will catch, and will not pass over the humeral surface. In

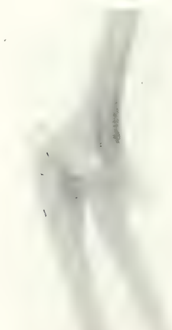


Fig. 256.—Front view of same case (outlines added).

Fig. 257.—Old backward dislocation with avulsion of part of external condyle.

Drawing from plaster cast in the author's collection. The bow-string prominence of the triceps tendon is well shown.

fact, it will so pass without trouble, and this method has always seemed to me unnecessary, though unquestionably effective; it is open to the

objection that it must further strain the remainder of the anterior ligaments, etc., already seriously torn.

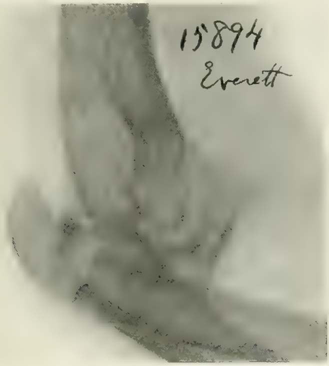


Fig. 258.—X-ray of original of cast shown in Fig. 257.

Fig. 259.—Photograph of outward and backward luxation with fracture (loose) of the external condyle. Reduced without incision; good functional result, but only partial union of condyle.

The reduction over the operator's knee (Fig. 266) is open to the same objections.

Fig. 260.—*X*-ray of the case shown in Fig. 259.

Another method, gentle, showy, and moderately efficient, is shown in Fig. 265.

Neither this last nor the second method described practically ever calls for anesthesia, while the others either may or may not, accord-

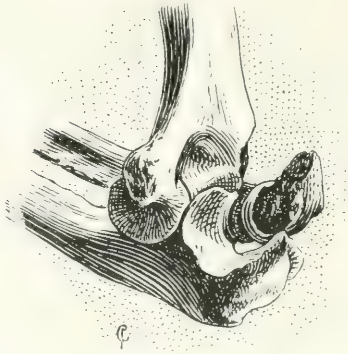


Fig. 261.—Bone sketch, showing conditions in same case as Figs. 259, 260.

Fig. 262.—Reduction by shoving with the thumbs on the olecranon, thrusting forward and downward.

ing to the time elapsed, and according to the sensitiveness of the individual. With very muscular patients reduction without anesthesia

Fig. 263.—Reduction by flexion, traction, and counterextension.

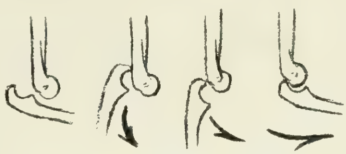


Fig. 264.—Reduction by hyperextension, downward traction, and flexion; diagrammatically represented.

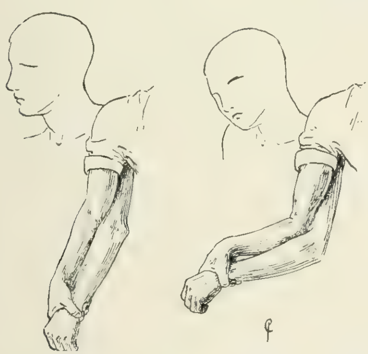


Fig. 265.—Reduction of posterior luxation by flexion and leverage, the operator's elbow being used as a fulcrum. This is a spectacular, but fairly efficient, method.

Fig. 266.—Reduction of posterior luxation by pulling and flexing the arm over the operator's knee as a fulcrum.

may be injurious; under ether the muscles slacken and less force in manipulation suffices.

OUTWARD LUXATION

Of the other forms, the outward displacement is least uncommon. Not infrequently a dislocation that must be classified with backward displacements lies also somewhat outward, but a real *outward* luxation is rare—that is, a displacement such that the coronoid is still in front of the humerus. (See Figs. 269–272.)

Three varieties of such displacement have been described:

Fig. 267.—Dislocation backward and slightly outward; it was readily reduced. (Author's case.)

1. Complete (without pronation).
2. Complete (with pronation).
3. Incomplete.

In the *complete* forms not only are the lateral ligaments gone, but necessarily the anterior ligament as well, and the destruction of the soft tissues is necessarily great. The distinction between the two forms is that in the first the forearm is displaced directly out and up, *without* rotation (Fig. 273); in the second there is such rotation and we have a position like Figs. 269 and 274.*

In the *incomplete* form the ulnar sigmoid has not entirely left the articular surface, and assumes the position of Fig. 275, with more or less rotation. Hutchinson† described an autopsy on a case of this incomplete type—a case in which reduction was done during life, but postmortem the luxation was readily reproduced. The sigmoid notch embraced the external condyle; the head of the radius projected. The annular ligament was intact, but both lateral ligaments were completely torn, and rents appeared in the anterior capsule. No fracture of the epitrochlea was noted. Hueter, however, found epitrochlear fracture in resections done for this dislocation, as did Stimson. The displacement of the epitrochlea is apt to be over onto the trochlea itself; it may lie in the way of reduction. This particular form of outward luxation is probably the one least often found.

* A further "supracondylar" form is simply an exaggerated form of the second type.

† Hutchinson, Med. Times and Gazette, 1866, vol. i, p. 410.

Diagnosis.—Diagnosis of outward luxation in any of its forms differs decidedly from that of the backward displacement. There is broadening of the elbow laterally, which is very great in *complete* outward luxation—practically a doubling of the diameter of the elbow. In the lesser forms it is still, of course, a very obvious deformity. These luxations tend to show more flexion than the backward luxation. In the last two forms the elbow may be held nearly at a right angle. In the first form flexion is less. In the complete luxation of the first class pronation is impossible. In the second class the hand is already pronated, and the front of the forearm looks down and inward. The arm is flexed, and there is adduction of the forearm. In the incomplete type pronation and supination are not necessarily interfered with, and flexion and extension are only partially limited. In all forms there is a considerable range of motion compared with that of the backward displacement, because in these outward displacements there is absolutely no *bony* check to either extension or flexion. In the severest cases, with great tearing of ligaments, muscles, etc., an astonishing range of motion is reported.

Fig. 268.—Outward (and backward) luxation at the elbow, before reduction (photograph by Dr Loring B. Packard, City Hospital Relief Station).

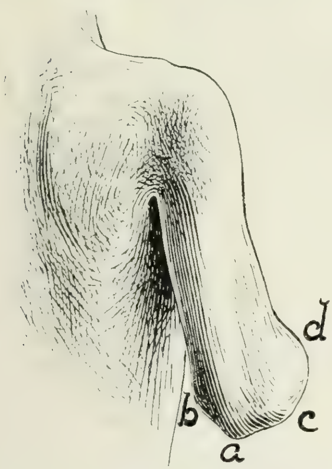


Fig. 269. — Outward luxation (sketch of case): *a*, Trochlea; *b*, internal epicondyle; *c*, olecranon; *d*, head of radius.

Diagnosis is in the end, of course, dependent on the exact recognition of landmarks, or on the x-ray. Most serviceable of these landmarks is one not to be felt under any normal condition—the lower inner edge of the *trochlea*. When the olecranon is out of the way, this may appear as a very sharp edge, running forward and back near the internal condyle. (See Fig. 276.) It is, when apparent at all, the most prominent point on the front and lower surface of the flexed elbow, and the skin is stretched tightly over it in such fashion that its contour can readily be made out, and it is unmistakable.

Fig. 270.—*X*-ray of case shown in Fig. 269, seen from above.

Fig. 271.—Same case, view from the side.

Fig. 272. Luxation outward (photograph by Dr. Loring B. Packard, City Hospital Relief Station).

Fractures complicating these somewhat unusual luxations are not particularly likely to be diagnosed until after reduction. The presence of crepitus may tell us that there is a fracture. Just what the fracture is it may be impossible to say until reduction has restored more comprehensible relations. The external condyle is the only point likely to be broken in the complete cases. Curiously enough, in the incomplete —not often in the complete—cases, epitrochlear fractures are reported.

There is no peculiar liability to nerve or vessel lesions with any of these outward luxations.

Reduction of Outward Luxations.—The reduction of an outward dislocation is not essentially different from that of the backward except that an *inward* shove or swing must be substituted for the forward motion.

Reduction is easy in proportion to the extent of laceration. The manœuvers advised include hyperextension, with special precaution not to produce a posterior dislocation, combined with traction and with

Fig. 273. — Outward luxation *without* rotation of the forearm bones.

Fig. 274. — Outward luxation *with* rotation of the forearm bones (seen from the outer side).

Fig. 275. — Incomplete luxation. Luxation outward, with *rotation* in *abduction*. The olecranon is still partly in contact with the articular surface.

an inward shove on the forearm. If the radius has a point of bearing on bone, then abduction with the arm (extended) will help clear the joint for reduction by separating the ulna from the humerus. Then an inward shove is used to complete the reduction.

Apart from the possible jamming of an epitrochlear fragment into the joint, there is no difficulty about the reduction. The epitrochlea may become displaced in reduction into the joint between the humerus and the sigmoid fossa.

Jamming of this sort is evident from failure to restore full motion, and from an *abduction* deformity, to say nothing of the fact that the epitrochlea is missing. The x-ray may help. In the two cases I have seen the diagnosis was far from certain until operation.*

* These cases, both in small boys, both first seen after reduction, the first a case of my own, the second seen with Drs. F. B. Lund and E. H. Nichols, are perhaps unique in that actual removal of the fragment from the joint was carried out on *recent* cases. Both operations were done for nerve-pressure. All things con-

The method of getting the fragment out of the way, recommended by Albert, is as follows:

Flex the arm to a right angle, and separate the joint surfaces by pulling down on the upper part of the bent forearm; then swing the forearm inward.

This is supposed to give more room for the epitrochlea to slide out of the way. It has been used successfully.

Fig. 276. — Outward luxation, showing the projection of the edge of the trochlea. Right elbow, seen from the inner side and from behind (schematic). Fig. 269 also shows this prominence of the trochlea.

Conversion of the outward dislocation into a posterior dislocation, and then a reduction of this luxation in the usual way, has been suggested as a way of getting around this epitrochlear difficulty. If these manœuvers fail, the only thing to do is to cut down and remove the troublesome fragment. It cannot unite, and at best it would form a loose body in the joint, giving much trouble later.

Prognosis.—Except for the difficulty with the epitrochlea, reduction in all the cases of this class seems uniformly easy, and permanent in recent cases. In the record of old cases the good function said to have been acquired where the dislocation remained *un*reduced is somewhat surprising. A perfectly serviceable range of flexion and extension is reported in several instances.

INWARD DISLOCATIONS

These are always incomplete. In part, they really belong to the isolated luxations of the ulna. If we consider the matter strictly, the radius usually does not really leave the capitellum at all, but is simply *shifted* on it.

However, in some cases these luxations do represent a lateral shifting inward of *both* bones together.

The conditions are as follows: The sigmoid fossa is in contact with the epitrochlea. The radius lies on or below the trochlea, in front of it, or behind and below it. The olecranon fossa is empty. The lateral ligaments have both been found torn in the cases examined anatomically. The anterior ligament is not largely torn.

Diagnosis.—The diagnosis rests purely on identification of landmarks, and on the presence of some inward deviation of the axis of the forearm. There is nothing characteristic as to position or limitation of motion.

Reduction.—Reduction is accomplished by extension, traction in

sidered, the original luxations probably were *incomplete* outward or rotatory luxations. There are no exact data, but the extensive tearing of the inner part of the capsule and the position of the trochlea make this probable. The most surprising thing was the fact that the presence of the epitrochlea in the cavity of the joint could not be demonstrated clearly by position or motion until the fragment was actually found and extracted.

the axis of the arm, and a direct push outward. This reduction in the cases on record seems never to have presented any particular difficulty.

Results.—There seems to be no especial tendency to recurrence; the results are good; even with the luxation unreduced the functional result may be fair, with considerable motion in the joint.

DISLOCATIONS OF RADIUS AND ULNA FORWARD

This is a rare form of dislocation, present perhaps sometimes as the end position of a dislocation originally of some other type, but also apparently possible as a primary position. In considering this type, certain cases really consisting of dislocation of the radius forward with ulnar fracture are sometimes classed here; they should be excluded.

Not much is known about the mechanism. In some cases of this lesion on record there seems to have been a direct thrust forward, exerted on the much bent elbow by the force of a fall.*

Lesions.—The lesions are, so far as the data go, rupture of both lateral ligaments and of both anterior and posterior ligaments of the joint, more or less damage to the triceps (completely torn loose in Canton's case), and more or less damage to the muscles arising from the condyles. Naturally, there is great probability of nerve injury. The olecranon is wholly dislocated and lies in front of the joint.

Fig. 277.—Forward luxation (schematic). The arrows show the direction of the force needed to reduce the displacement.

Fig. 278.—Forward dislocation with subsequent extension of the arm (schematic). Must be converted to type of Fig. 277 before it can be reduced.

Symptoms.—The limb may be extended, in which case the olecranon lies up in front of the joint, or it may be flexed, as in Staunton's case, in which case the end of the olecranon rests above the condyles in front. There may be considerable outward displacement combined with the displacement forward.

Reduction.—Reduction is accomplished by bringing the joint into flexion and then doing a distraction of the joint surfaces over the operator's knee and pushing the olecranon back into place (Fig. 277).

The prognosis depends upon the nerve and muscle damage.

The above applies to complete luxations. *Incomplete* displacements in this direction, with the olecranon lying *on*, not in front of, the trochlea, seem not to be so uncommon, and are, of course, less serious, and are reducible by pushing the flexed forearm downward and rotating it into place as extension is carried out.

* Staunton (Brit. Med. Jour., 1905, vol. ii, p. 1520) reports a case so caused. Elbow held at 130°, permitting slight motion: radius and olecranon $2\frac{1}{4}$ inches up above the condyles. Refers to "about twelve" cases on record.

DIVERGENT DISLOCATION OF THE RADIUS AND ULNA

This is an extremely rare accident, necessarily the result of extreme violence. To produce it, it is necessary not only that the strong orbicular ligament should be ruptured, but also that the oblique ligament and some part of the interosseous membrane should be torn. Not only are these very resistant structures, but it rarely happens that a force can act in such *direction* as to tear them.

The dislocation is divided into two forms, the first where the radius is dislocated forward, the ulna backward; the second where the radius goes outward, the ulna inward, the whole width of the humerus lying between them. The first type is the less uncommon, though but few cases have been reported. The appearance of the joint in the first type seems, from the descriptions, to be not very unlike that of ordinary backward dislocations. In fact, several of these cases have been reduced, so far as the ulna was concerned, before the displacement of the radius was recognized.

Even if this displacement is recognized, probably the best reduction is to put the ulna back in place, as we handle backward luxation, and then to reduce the radius by extension and pressure, as with the simple forward luxation of this bone. There seem to be no data as to details of after-treatment and results. Probably the best position for treatment would be acute flexion, relying upon the traction of the triceps on the fascia about the elbow to maintain the position.

Fig. 279.—Divergent luxation, the ulna passing behind, the radius in front of the humerus (schematic).

Fig. 280.—Divergent luxation. The ulna has passed to the inner, the radius to the outer side of the humerus (schematic).

How far repair of ligaments or the formation of a new annular ligament may be relied on cannot be stated on the basis of published experience, but, judging from similar cases, probably such a ligament would be formed after sufficient fixation without too early use of the limb.

The other type is so rare as to be a mere curiosity of surgery. The diagnosis would obviously be made from the extreme widening, without the presence of crepitus, with the olecranon presenting to the inner side of the internal condyle, the radius in corresponding position on the outer side, and the intact humerus between, recognizable by the peculiarly shaped surface of the trochlea. The extreme tearing of ligaments necessary to this luxation would make reduction easy. The best position for treatment would probably be acute flexion with due regard to avoiding overtension and pressure on the vessels, and with enough lateral pressure to avert any tendency to fresh lateral displacement.

AFTER-TREATMENT OF ALL ELBOW LUXATIONS

The after-treatment of these cases, as in all uncomplicated luxations, calls for a rest, but not necessarily for absolute fixation, for two or three weeks.

There is a definite risk of recurrence of elbow luxations, but reluxation is possible, so far as the writer's knowledge goes, only when considerable extension has been permitted within a few days. Possibly two weeks would be a safe limit; at least as early as ten days some motion should be begun, as some loss of motion is, especially in adults, far more frequent than recurrence of displacement. After three weeks it has been the writer's custom to leave the patient to his own devices, with the caution not to use the arm for work, but *not* to keep the arm quiet.

PROGNOSIS OF ELBOW LUXATION

Not infrequently the recovery of full motion takes many weeks; exceptionally, there is permanent loss of part of the arc of motion. Anything like ankylosis I have not seen follow reduction, however late the reduction was accomplished.

Nerve Complications.—Motor paralysis is the most serious of the sequelæ. This most often is a result of the trauma, not of the reduction, but because of possible doubt in this regard we should test innervation *before and after* manipulation, both in luxations and also in fractures about this joint. Any of the nerve-trunks may be involved, the ulnar oftenest, and the musculospiral more often than the median.

How readily the ulnar nerve may be injured is instanced by a case in which I reduced an old luxation by open incision with sheer cutting of ligaments, *not by traction*. The reduction was followed by a very definite partial paralysis of the ulnar motor supply, and a partial anesthesia, which, however, improved within the week and was well within about six weeks.

Similar mild nerve injury shows itself very commonly directly after dislocation. Severer lesions calling for operation on account of pain or paralysis, like the two cases cited (page 229), are rather rare.

On the whole, the *proportion* of nerve injuries in elbow luxation is small, and the eventual prognosis is usually good.

LUXATION OF THE RADIUS ALONE—BACKWARD

This is very rare. The mechanism is doubtful; the lesion may apparently occur from blows directly on the radius, or as the result of a force that drives upward from the hand, the elbow being flexed. Presumably, an upward drive during forced pronation would produce it.

Lesions.—The lesions are not known from any dissection of fresh

cases; presumably the posterior ligament is torn, and perhaps sometimes the annular ligament as well. There is at least one case on record where there was also a splitting off of part of the inner side of the radial head.

Diagnosis. Clinically, the diagnostic feature is the presence of the radial head behind its normal site, just to the rear of the external condyle. According to Langenbeck, there is obvious deformity on the radial side, but the radius is not prominent. *Its hollow end is,* however, *palpable.* The olecranon is not displaced.

The arm is held in extension or in slight flexion, and is pronated. *No movement is considerably restricted except supination,* but there is some limitation of flexion and extension.

Reduction is by direct pressure on the radial head, with or without traction. No *especial difficulty* is recorded in the reduction, but there is said to be some tendency to recurrence. Treatment must guard against this by pad pressure, with the arm at a right angle on a splint or in acute flexion.

Fig. 281. Backward luxation of the radius, necessarily combined with a rotation of the ulna on the trochlear surface of the humerus (schematic).

Fixation must be continued long enough to allow repair of the orbicular ligament, or formation of a new ligament if the ligament has been completely ruptured. This will mean not less than three or four weeks of fixation.

According to Stimson, in old unreduced cases the motion, even in supination, is very fair. Just how this can be so is a puzzle; Langenbeck says it was not so in his case. It would seem that the same forces must act to prevent supination in old traumatic cases that make supination impossible in the so-called "congenital" cases of this class.

There are no data at hand to show how much overgrowth of the neck of the radius results in these luxations from relief of pressure exerted by the external condyle, but in youthful cases it probably would be considerable. In the "congenital" cases it is often enormous.

If the disability warrants it, there is no reason why an old backward dislocation of the radius at the elbow may not be treated by resection of the radial head and by stitching the altered capsular ligament back nearer its normal place. I have done this operation twice for pathologic backward luxation, produced by overgrowth in late hereditary syphilis, with admirable results.

The resection of the radial head not only does not cause ankylosis, but gives a joint not weaker than the normal.

DISLOCATION OF THE RADIUS OUTWARD

This differs only by slight variation of position from the backward dislocation of the radius. As to mechanism, there is no question but that direct pressure exerted upward along the radius, with the elbow flexed and fixed, may produce this dislocation. Wagner* reported three cases so produced, in two of which a part of the inner edge of the radial head was broken of, apparently driven off as the head passed under the condyle. Loebker† reported two similar cases.

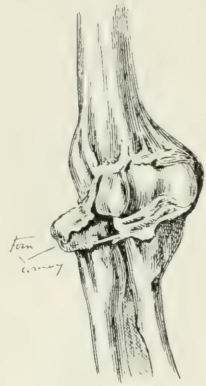


Fig. 282.—Luxation of the radius *outward*, with some outward displacement of the ulna, and with tearing of the orbicular ligament (after Cooper's plate).

Lesions.—Our knowledge of the lesions rests largely on the observations during excision of fragments by these operators. The previous specimens of this lesion, as with other luxations, were very old cases, showing changes that were probably in part secondary. Apparently in these cases of Wagner and Loebker the pressure on the hand with the elbow bent and supported (these were accidents in pushing miners' coal-cars, the arm being caught between cars) caused an ascent of the radius on the ulna. The orbicular and oblique ligaments must have been stretched, though not obviously torn.

Reduction.—The reduction is the same as for the backward dislocation, only with a different direction for the pressure—that is, with *inward* pressure over the radial head.

Prognosis.—Apart from the results of the associated fractures noted above, there is nothing out of ordinary as to the prognosis.

DISLOCATION OF THE RADIUS FORWARD (WITHOUT FRACTURE)

This dislocation is relatively not uncommon. Certainly it is the commonest of the *isolated* radial dislocations.

In a good many cases fracture of the ulna close to the joint is associated with some displacement of the radius forward, as noted below.

Isolated dislocations of the radius forward, in the stricter sense, may result from direct blows, apparently also from the torsion of a fall on the hand, and probably also as a result of muscle action by the biceps.‡ The dislocations are, as a rule, incomplete, in the sense that the radius does not entirely leave the surface of the capitellum.

Lesions.—It is not necessarily true that the orbicular ligament must

* Beilage zum Centralbl. f. Chir., 1886, xiii, 93. † *Ibid.*, p. 91.

‡ The biceps may rupture its tendon or tear it from its insertion, or it may luxate the radial head.

be torn through in this dislocation, though no doubt it is so torn in some cases. Probably the anterior ligament of the elbow is necessarily torn, at least in part. The diagnosis of these cases rests on the following points:

Diagnosis. Flexion is limited at or about a right angle by definite *bony* resistance, from contact of the capitellum with the humerus above the condyle (Fig. 285).

Extension is limited by the changed relation of the biceps (Fig. 286).

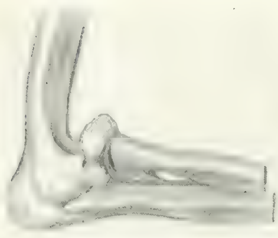


Fig. 283. Luxation of the radius forward (after Cooper).

The radial head cannot be found in its normal position, and the front face of the external condyle is exposed below.

The radial head is present, and rotates normally, at a point *above*, and a little internal to, its normal position.

Reduction.—Reduction presents no special difficulty in fresh cases. The tendency to recurrence is great on account of the pull of the biceps on the radius.

Acute flexion necessarily assures reduction, and makes any considerable pull on the radius impossible.

After-treatment.—Acute flexion is the best position to keep the arm in during the time of repair.

Old luxations of this type are serious because of the limitation of flexion. Open operation, reduction, and retention by means of a new orbicular ligament made of fascia or of kangaroo tendon should be considered in such cases. I have done this in one case of old forward luxa-

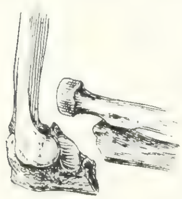


Fig. 284.—Luxation of radius forward, with ulnar fracture (schematic).

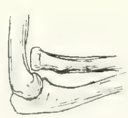


Fig. 285.—Limitation of motion with forward luxation of the radius (diagram).

Fig. 286.—Limitation of extension (due to biceps tendon) in forward luxation of the radius (diagram).

tion with ununited ulnar fracture. The radius staid in place, rotating freely, and showed no tendency to loosen, even though bony union of the ulna was never obtained, thus throwing exceptional strain on the radial fastenings (Figs. 436 to 439).

Radial Luxation With Ulnar Fracture

The radial head may be displaced in conjunction with fracture of the ulna high up. This means, of course, a deviation of the axis of the ulna. The radius, as a whole, keeps its alinement with the line of the

ulna below the fracture, held by the interosseous membrane. This may determine dislocation of the radius *outward* or *backward* or *forward* as the case may be. Whether there must necessarily be a tearing of ligaments at the time of accident or whether this luxation or subluxation may be purely a secondary result of bad position of the fracture I do not know. Excepting that such a fracture is hard to hold in place because it lacks the support of the radius, this dislocation is of no great moment: once reduced in flexion, the luxation is not likely to occur except for the same cause that first produced it. (See Figs. 436 ff.)

DISLOCATION OF THE ULNA ALONE (ON RADIAL HEAD AS A CENTER)

There are two forms only: the *backward* type and the *forward* luxation. The backward displacement is not very rare.

Luxation of the Ulna Alone, Backward

Whether it is called backward or outward is a matter of terms; the fact is that the lesion is a rotatory luxation of the ulna, up, back, and outward, swinging on the head of the radius as the center. The radius itself is practically undisturbed.

There is necessarily a rupture of the internal lateral ligament. The ulna slips back and up until, as shown by Roberts in an autopsy on a recent case, the coronoid rests in the olecranon fossa.

Symptoms.—Clinically, the symptoms are those of an arm held in extension, or very nearly extended, with no possibility of flexion, with an olecranon very prominent, though not very high, and with a very definite inward deviation of the axis of the forearm, in the position of a "gun-stock deformity." There must necessarily be some rotation, to allow the ulna to slip back without moving the radius; Roberts mentions that the front of the humerus *faces outward*. This rotatory displacement is hardly appreciable clinically.

The exact mechanism of production is not clear. Apparently, the lesion may be produced by force applied to the hand with the arm at or near full extension.

Reduction is carried out by hyperextension alone, or by supination followed by active *abduction* of the arm. It presents no difficulty, and there is no special liability of recurrence.

Luxation of the Ulna Alone, Forward

This has been well described by Stimson from observation of a fresh case.

Lesions.—The lesion is essentially conditioned on a tearing of the internal lateral ligament; in Stimson's case there was also an extensive tearing of flexor muscles in front of the internal condyle. The displacement brought the tip of the olecranon below and a little in front of the trochlea, without any great disturbance of the relations of the radius. The

arm was held at a right angle—some motion was possible. There was lateral mobility outward; there was an abnormal abduction, and further abnormal abduction was also possible.

Reduction is simple—by rotation and *ad*duction.

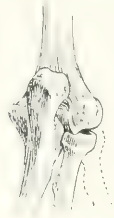


Fig. 287.—Luxation "of the ulna backward," really a *rotatory* luxation. The dotted line shows the normal position of the radius in relation to the humerus (schematic).

Fig. 288.—Anatomy of *sub*luxation of the radial head. The lateral ligaments and the orbicular ligament shown in black.

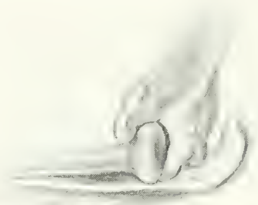


Fig. 289.—Dislocation of the ulna backward (rotating on the radial head) (after Cooper's drawing from a museum specimen).

SUBLUXATION OF THE HEAD OF THE RADIUS IN CHILDREN (MALGAIGNE'S LUXATION)

This is a common injury, long known and much discussed as to details. The only thing, curiously enough, on which every one is agreed is its mode of production. It occurs only in small children, under four years of age, and results from the child being lifted, or helped along, by the mother or nurse, who grasps one hand near the wrist (Fig. 290). The sequence of events is perfectly typical.

The child that has been so lifted makes some complaint of pain, and forthwith refuses to use the arm. So long as the arm is quiet there is no trouble, but the child will not use it and objects to having it handled.

The arm is held in a position which is constant (see Fig. 291); this consists of a partial flexion of the elbow with pronation of the hand.

Handling of either elbow or hand seems painful. Flexion and extension of the elbow are not checked, but supination is limited, and usually it is very much limited. If no reduction is attempted, this lameness persists for a considerable time. There is at no time anything definite to be *felt* at the elbow. There is little or no swelling, and it

requires some imagination to feel the alleged increased distance between the radial head and the condyle.

Two theories (among many) as to what actually occurs in these cases, may be mentioned: A folding of the capsule between the bones has been held to explain the lesion; this presupposes a forced pronation. The nature of the force producing the accident renders this impossible. The child's arm is in extension when the injury occurs, and a forced pronation of the elbow cannot be produced in a young child in this position, for pronation of the *extended* arm happens mainly in the *shoulder-joint.* This consideration seems to dispose of this theory.

The other theory is unproved, but probable. That theory is, that the radial head, by direct traction on the wrist and hand, is pulled part way down through the orbicular ligament and jammed there. Exactly how it is held so as to allow *some* rotatory motion no one professes to say, but this theory seems to correspond closely with the clinical facts. It is the original theory advanced by Duverney many years ago. On examination of one of these cases, the history, the disinclination to use the arm, the characteristic attitude, and the sharp limitation of supination, without limitation of other motions, and without other obvious injury, is enough to establish a diagnosis.*

Fig. 290.—Shows how to lift a child in order to produce subluxation of the head of the radius.

Fig. 291.—Attitude in subluxation of the radial head (drawn from photograph of a case of the author's).

* It must not be forgotten in the differential diagnosis that simple slight contusion about the joint or slight strain may, in a small child, give an apparent disability so far as use is concerned that is out of all proportion to the severity of the injury.

Reduction.—Reduction is performed by taking the lower end of the humerus firmly in one hand so as to prevent rotation, then bringing the arm into partial extension with slight traction downward, then pronating slightly, then supinating with a gentle shove upward from the wrist, then flexing the elbow. (See Fig. 292.)

Then test the pronation and supination (Fig. 293). If it is necessary, repeat the procedure. When all motions are normal, the reduction is complete, and within a few hours the child is ready to use

Fig. 292.—Reduction of subluxation: *a*, Extend and supinate under moderate traction; *b*, flex and pronate.

the arm. There is really no necessity for any apparatus whatever, for the lesion is one of stretching, not of tearing of ligaments.

Results.—There is no tendency to recurrence and no liability to sequelæ. For the sake of the mother's peace of mind it is commonly well to pin the child's dress-cuff to the breast of the dress on the opposite side, forming a simple sling, and allowing the child to convince the mother that there is nothing wrong. This they always do within twenty-four or forty-eight hours.

One point of some interest is as to what becomes of these cases *untreated.* Personally, I think they must in time reduce themselves.

The accident is very common, and is treated usually by the family doctor, if treated at all. Cases must escape treatment with some frequency, but we never hear of cases or see cases in which loss of motion is or can be traced back to this injury in infancy. It has been supposed that some cases of forward displacement of the radius met with later might have such an origin, but this is very doubtful. Chassaignac, who considered these cases as nerve injuries, treated a lot of them and

Fig. 293.—Final movement; pronate and supinate the forearm to test reduction.

treated them without attempts at reduction; even under such treatment he noted no bad end-results.

The following is given as a typical case, one of many:

E. D., male, two years old. Previously healthy.

November 3, 1905: About twenty-four hours ago the mother lifted the child by one hand. The child struggled at the time. Nothing was noticed until shortly afterward, when the mother noticed that the child showed neither inclination nor power to use the arm. This condition did not improve. The child was not, however, in apparent pain. The child showed the characteristic attitude seen in the cut, and

absolutely refuse to use the arm or move the hand, but seemed to have no pain. Movements of the elbow proper were not limited at all. Pronation was normal; supination only one-third the range of that of the other side. Resistance firm, but *elastic*.

Reduction by slight traction, with moderate pronation, followed by sharp supination, and then an upward shove. There was a sharp but soft click, and on testing, all motions of the elbow were found to have become normal. Put up with the dress-sleeve as a sling.

November 6: Reported today. Began to use the arm within five hours after reduction. No complaint since then, and examination shows nothing abnormal.

CONGENITAL LUXATION OF THE RADIUS

Such luxation may be forward, back, or outward, most commonly backward according to Blodgett's summary of 51 reported cases.*

Congenital luxation of the radius involves loss of motion; if forward, the loss is in flexion; if backward, there is overgrowth of the radius, and extension is checked.

* Blodgett: Amer. Jour. Orthop. Surgery, January, 1906.

CHAPTER XV

FRACTURES OF THE HUMERUS NEAR THE ELBOW

These fractures are very common. In general, they are rated as serious lesions. A great deal of discussion has been wasted on the question of the method of treatment best adapted to produce the best angle for the stiff elbow likely to result. As a matter of fact, ankylosis is rare, and, excepting for certain extremely severe compound and complicated fractures in adults, the results are by no means as bad as the literature would lead us to suppose. The whole subject of elbow fractures from the point of view of actual practice has been vague, in my opinion, for the following reasons:

A. The fractures occurring in children and adults have been, unwisely, considered together. For all practical purposes they are very distinct, indeed.

B. The exact lesions have not been well understood and dealt with, even since the use of the x-ray has become more general.

C. The supposed end-results have been judged as they appear soon after splints have been removed, at a time when they show up very badly, and do not represent end-results at all.

Elbow fractures in adults are apt to be the result of extreme violence, occurring either as the result of direct crushing in machinery accidents, or from hard falls on the elbow. The adult elbow seems rarely to break as a result of falls on the hand. Being a result of direct violence in many cases, these fractures in adults are not rarely compound, and even when they are not compound, the separation of fragments and the damage to soft parts make them very hard to handle and very serious.

Elbow fractures in children, on the other hand, not uncommonly result from *slight* blows or falls. They differ in lesion from those of the adult inasmuch as they tend to follow the epiphyseal lines and are apt to be accompanied with comparatively little damage to the soft parts. They are almost never compound, except in cases where there is a tearing away of the *whole* epiphysis of the lower end of the humerus from the shaft.

Astonishingly bad results as to deformity may occur in children as the occasional result of bad reposition, but when cases are discharged at the end of six or eight weeks, even the good cases look discouraging.

If these cases in children are followed up six months or a year after the injury, we find a very different condition. The average fracture in children is apt to result better (as far as function is concerned) than

even the most favorable adult case, and out of a large experience of this sort of cases the writer has rarely found any ankylosis in a child or even any loss of motion of any serious moment. The rule is practically perfect function, with much or with little deformity according to the lesion and to the skill used in treatment.

It is for the reasons given, then, that elbow fractures will here be separated arbitrarily into two classes—those of adults and those of children.

ELBOW FRACTURES IN ADULTS

The common lesions are:

(*a*) Supracondylar fracture.
(*b*) T-fracture.
(*c*) Fracture of the external condyle.
(*d*) Fracture of the external epicondyle.
(*e*) Fracture of the capitellum.
(*f*) Fracture of the internal condyle.
(*g*) Fracture of the internal epicondyle.

There are also certain fractures that cannot be classified, in which there is very severe comminution in *all* directions.

Fig. 294.—Humerus from the front; shows the epiphysis of the internal epicondyle still ununited with the shaft.

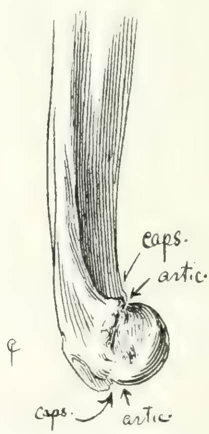


Fig. 295.—Right humerus from the outer side. Arrows show the limits of the articular surface and the attachments of the capsule.

Of those above listed, (*e*), the fracture of the capitellum, is extremely rare, and (*d*), the fracture of the external epicondyle, is met with only as a result of penetrating wound or as a complication of luxation.

The others occur not uncommonly, and are to be looked for.

Symptoms.—Common to all fractures in this region are: pain, dis-

ability, and swelling, severe in proportion to the trauma; not necessarily severe in fractures of a single condyle or epicondyle.

Very severe swelling is apt to be a sign of T-fracture or, at least, of a break above the joint.

T-fractures are relatively apt to be compound.

The formation of blebs has here the same significance as an indication of grave damage that it has in fractures of the leg. It is commonest with supracondylar and with T-fractures.

The *absence* of swelling on one or the other side of the joint is apt to be of help in locating the lesion.

The position of the arm, and the rotation of the forearm in pronation or supination, are not constant enough to be of any value in diagnosis. The detail diagnosis rests upon the recognition of landmarks and of their relations and on abnormal mobility. If the landmarks are not accurately recognized, accurate diagnosis is impossible.

Supracondylar Fractures

Supracondylar fractures are apt to occur at any height, but lie most often close above the condyles. Almost always the fracture-line is oblique *up* and *backward*. *Lateral* obliquity is more often upward and outward than in the reverse direction. Kocher separates an extension type, oblique up and backward and displaced backward, from a flexion type with opposite obliquity and displacement. It is perhaps too much to assume that these always result from flexion and extension respectively, but certainly in the common type, resulting from extension or backward thrust, the obliquity is upward and backward, and both displacement and rotation are backward, as *would* result if hyperextension were the cause. The cases of obliquity up and forward that the writer has met with have been very few, and with one exception have shown only a *rotation* of the fragment forward, and not a displacement *in toto*.

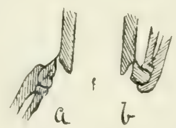


Fig. 296.—Kocher's "extension" (left) and "flexion" (right) types of supracondylar fracture: latter variety very rare. (Diagram.)

According to the height of the lesion, these fractures may or may not involve some tearing of the joint-capsule.

They are, however, above the joint proper, and do not involve the attachments of any essential ligaments. Ordinarily, the break is entirely loose except for the periosteum (which, in the backward displacement, is regularly stripped up from the back of the bone) and for the muscles. Impaction seems not to occur.

Clinically, we have the following cardinal points to bear in mind in diagnosis:

(*a*) There is free abnormal mobility, usually with crepitus, of the whole forearm and elbow on the shaft of the humerus in every direction except forward. The condyles move with the forearm (Fig. 302).

(*b*) The condyles show no broadening; their relation to one another is normal, and they move together in all motions.

(*c*) There is usually marked backward displacement, not unlike

Fig. 297.- Backward luxation (at left); normal elbow; supracondylar fracture (at right) (schematic).

Fig 298. Supracondylar fracture at twelve years; plate taken thirty-six years later (courtesy of Dr. McKechnie). Still shows displacement of fragments, in the way of the ulna on attempting full flexion.

Fig. 299. Front view: same case as Fig. 298; shows the lateral "gun-stock" deviation.

backward dislocation, but this displacement involves *condyles as well as forearm.* The radius and the external condyle are not separated. There is no hollow immediately above the olecranon.

(*d*) Extension is free except as limited by pain; flexion is apt to be hindered by impact of the lower end of the shaft on the forearm bones.

Fig. 300.—High "supracondylar" fracture, more strictly a low shaft fracture, not always easily differentiated (without the x-ray) from fracture close to the joint.

(*e*) The lower end of the shaft may be felt lying well forward of its normal relation (feel for it as in Fig. 246).

(*f*) The deformity recurs after reduction.

These rules apply to the usual backward and the backward and

Fig. 301.—Displacement (extreme) in supracondylar fracture (after C. Beck). The spur is the lower end of the shaft.

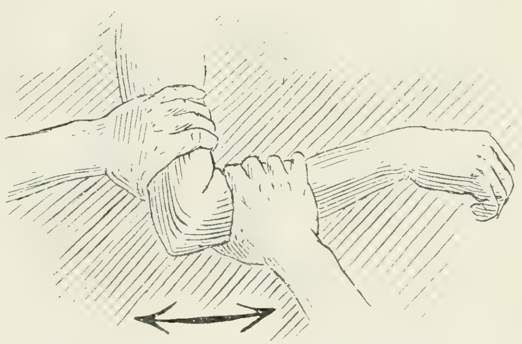


Fig. 302.—Test for mobility of the forearm, *with the condyles*, forward and back. The shaft of the humerus is held firm.

outward forms: points *a* and *c* apply to all save the rare subperiosteal fractures at this point, which cannot usually be more than suspected until an x-ray plate is taken.

If the displacement is *forward*, the end of the shaft will lie *above* the olecranon. The elbow will be in front of, not behind, the general direction of the shaft, and extension, not flexion, will be interfered with.

In *no* case of supracondylar fracture is motion in pronation and supination interfered with, and some motion may always be obtained in flexion and extension.

In the nature of things there must be shortening of the arm in these cases, and this may be measured from the spur on the acromion (Figs. 133, 134, 224) to the external condyle, but this is a measurement peculiarly open to error, and this test *alone* is of little avail.

T-Fractures

T-fractures present a somewhat more complicated problem. They may be precisely like the supracondylar, save for a split into the joint, without appreciable displacement.

It may be difficult to be sure of the widening at the joint or of the movement of one condyle on the other, or the displacement may be so great that the end of the shaft actually descends between the fragments. In these severer

Fig. 303.—Old T-fracture in adult (sketch of the Warren Museum, specimen 8974).

Fig. 304.—T-fracture in adult. Unusually high T-fracture (Warren Museum, specimen 1000).

cases the diagnosis of the T-fracture is simple—the question is only whether other and more complicated breaks are present. In the ordinary case, however, the diagnosis is not easy, for the widening of the elbow is a matter it is easy to be mistaken about if there is swelling, and the mobility of one condyle on the other needs some expertness to determine, for the fragments are still bound by ligaments to the forearm bones. It may be well to note that *crepitus*, gotten in testing

this motion, is *worthless;* it usually occurs not between the condyles, but between the upper and the lower fragment. This fact leads to

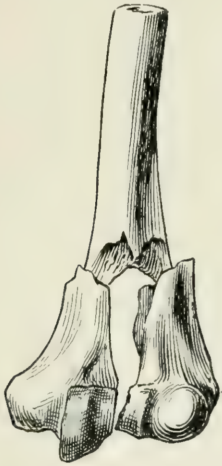


Fig. 305.—T-fracture of elbow. Man of forty-five, fell twenty feet and struck elbow, producing compound fracture. Arm amputated (Warren Museum, specimen 999).

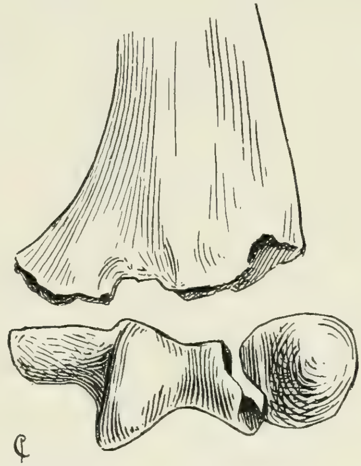


Fig. 306.—T-fracture in adult—*low* T-fracture (Warren Museum, specimen 1002).

Fig. 307.—Test for mobility of the condyles on the shaft of the humerus and on one another. The shaft of the humerus must be very firmly held. Best test for T-fracture.

frequent error. The diagnosis of T-fracture is often made where the break is simply supracondylar, or where *one* condyle is separated without any cross break.

Fractures of the External Condyle

Fractures of the external condyle run from the middle of the joint (or thereabouts) in a line upward and outward—a line of varying obliquity. The displacement is apt to be backward or outward, sometimes with outward rotation. The fragment is still held by the liga-

ments in nearly its normal relation to the radius. As noted above, actual joint luxation may rarely be combined with this fracture if the internal lateral ligament is torn.

Clinically, we find: (*a*) Swelling of the *outer* side of the joint only. (*b*) Tenderness only about the *outer* condyle. (*c*) Crepitus in this same region. (*d*) Mobility of the condyle under the fingers. (*e*) Recognizable deformity of bone—this is hardly the rule.

Valuable *negative* evidence is furnished by the *immobility* of the ulna on the humerus *forward* or *backward*. There is apt to be some slight abnormal play *laterally*.

There is no thickening or deformity about the internal epicondyle

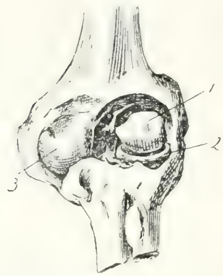


Fig. 308.—Fracture of external condyle alone, in adult; non-union: 1, External condyle; 2, radial head; 3, trochlea (after A. Cooper's plate).

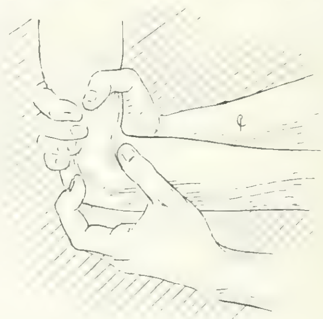


Fig. 309.—Test for mobility of the external condyle, the shaft of the humerus being fixed by the operator's other hand.

or condyle, or along the inner surface of the humerus. There is little or no ecchymosis or swelling on the inner side, and little tenderness.

Flexion and extension of the elbow are painful. Mouchet * says that pronation and supination are limited in this lesion, but in testing many cases I have found such limitation but once. Usually the freedom of this rotatory motion argues against high fracture of radius or ulna, *not* against condylar fracture.

The joint is often appreciably *broader* than normal. Usually no changed relation of the landmarks is appreciable except for this broadening.

Fracture of the External Epicondyle

Such fracture undoubtedly occurs, and may result from direct violence (*e. g.*, gunshot wound) or from traction as with luxation.

There is a plate of Gurlt's (much copied) showing bony union of an old fracture of the sort, that has dignified the lesion beyond its deserts.†

* Mouchet: Paris: G. Steinheil: Monograph, and Bull. Soc. Anatom., 1898, lxxiii, 811.

† I know nothing about the lesion except for one case in which a chip in this region had been torn off. This was merely a complication of other fractures with partial luxation.

Fracture of the Capitellum

This is the "fractura rotuli humeri" described by Kocher. He cites several cases; the writer has met with it once.* The lesion is simply a splitting off of the anterior articular face of the external condyle. How it occurs is not certainly known. The fracture is intra-articular, and the fragment lies free in the joint. The diagnosis rests simply on the presence of a foreign body of considerable size in the elbow-joint, found directly after an injury. It differs in no way clinically from the cases where a portion of the radial head is split off and becomes a foreign body. In two of Kocher's cases the fragment was displaced backward; in one, (as in the writer's case) it was forward. According to the position, either flexion or extension is seriously interfered with. The check to the movement of the joint feels exactly like that met with in a dislocation of a knee cartilage: it is a very definite checking, well described as like that of "a stone in a hinge." The amount of local reaction from this injury is very slight at first, but the disability is considerable. The fragment does not unite,† and would probably grow in size in time, as do other intra-articular bodies. The only treatment is an excision of the fragment. The results of such excisions as are reported were good. The fragment is easily accessible by an incision on the outer side of the joint, in front or behind, as the case may be, guided by the x-ray in each case.

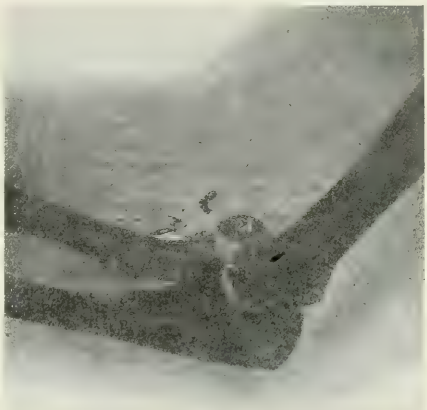


Fig. 310.—X shows loose fragment in front of the external condyle. *y* shows, apparently, the gap from which the fragment came.

FRACTURES OF THE INTERNAL CONDYLE

Internal Condyle (into the Joint); Fracture of the Trochlea

This lesion occurs less often than fracture of the external condyle. It presents corresponding signs. There is, however, a greater increase of lateral mobility, and, the ulna no longer being firmly held, there may be some mobility anteroposteriorly as well. Here, again, except for the broadening, the relations of the various landmarks are not disturbed.

* Cotton: Boston Med. and Surg. Jour., cxlix, No. 27, pp. 734–736, December 31, 1903.

† That is, it does not unite, as a rule. Gurlt and Hahn each record fractures with union, apparently belonging to this class.

Fractures of the Internal Epicondyle (Epitrochlear Fracture)

These are not intra-articular fractures in adults, and do not *per se* affect the joints at all. The epicondyle carries the origin of the superficial forearm flexors and of most of the lateral ligament, but the attachment of the latter is so close to the base of the epicondyle that it is not ordinarily involved in the fracture, and in few if any cases is it entirely torn loose. The epicondyle may be broken either by direct violence or by strain exerted through the muscles which have their origin from it.* This lesion usually occurs by fall on the hyperextended hand or from like violence.

Clinically, the injury is characterized by little reaction and swelling, without great immediate disability.

There is, however, an inability to use the hand somewhat disproportionate to the disability at the elbow, and hyperextension of the wrist is painful. This, of course, is owing to the special relations of this process to the superficial flexor muscles. The sensitiveness, swelling, etc., are all limited to the *inner* side of the elbow.

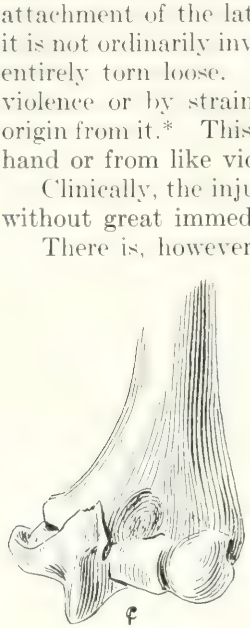


Fig. 311.—Isolated fracture of the internal condyle (united) (Warren Museum, specimen 3775).

Direct examination shows no obvious change in the relation of the landmarks. A prominence is felt at the usual point for the internal epicondyle, but on more careful examination this prominence proves to be shorter and blunter than normal, and without the posterior projection normally present. The ulnar nerve, instead of lying comfortably behind this hook-like process, lies *exposed* on a flat surface behind or near the tip of the shortened projection. (See Fig. 243.) On careful examination a thickening is often to be made out below and in front of the normal place for the epicondyle.

Very often, however, even in fresh cases, it is impossible to make out a definite fragment. The separation in very rare cases may be not forward, but backward and outward. This is said to be the case in some instances where this fracture complicates dislocation, and where the fragment, larger than usual, has carried some attachment of the lateral ligament by which it has been dragged back. I have seen it twice in cases where there was no dislocation, and where it was impossible to establish any tearing of the flexor origin, which would seem a necessary condition for this displacement.

A valuable point in diagnosis is the pain on *active finger flexion* or

* Up to about twenty years the lesion is apt to be epiphyseal separation, rather than fracture.

active pronation of the hand, due, of course, to involvement of the origins of the flexor and pronator muscles.

Later, there is a well-marked *selective* atrophy of all these muscles in such fractures, that recovers very slowly.

Compound Fractures.—Compound fractures have already been mentioned. Here and there the less severe fractures may be compound, but, as a rule, this complication attends the fractures in which there has also been great damage to the bone and to the deeper soft parts. It is for this reason that the net results in these cases are not very satisfactory. Even with the most careful technic there is a liability to sepsis, greater even than with most compound fractures about joints. Owing to the comminution of the bone and the poor nutrition of the fragments, sepsis

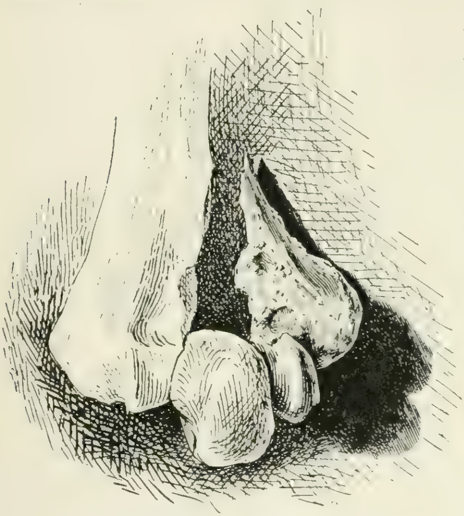


Fig. 312.—Compound fracture of humerus at elbow, with great displacement of ulna between fragments. The fragment shown to the right had to be removed (figure drawn from this fragment *direct;* the olecranon and the humeral shaft drawn from normal bones).

Fig. 313.—Comminuted compound fracture of elbow. Shows the fragments removed in an excision for primary sepsis (courtesy of Dr. J. B. Blake).

almost always entails necrosis, and the result is necessarily bad. If the wound can be kept clean, however, good opportunity is offered for accurate reposition and fixation by wire or absorbable suture, which procedures give better results than can possibly be reached in the "simple" fractures. Partial excisions give admirable results at times.*

Vessel Injuries.—Injuries of the vessels are not usual complications of elbow fractures; they occur only where the displacement is extreme. The brachial artery is the only one the injury of which need be seriously

* Case: C—. Machinery accident: Fracture of external condyle, compound Excision of condyle. Perfect result save for moderate gun-stock deformity. Is working in an iron-foundry. Reported by the writer in Boston Med. and Surg. Jour., 1906, clv, p. 644.

considered. The rupture of this artery is signalized by great swelling and by loss of the radial and ulnar pulses. This condition calls for prompt operation and ligature, in order that the removal of the swelling and pressure may give a chance for an adequate collateral circulation to establish itself. Such lesion is *not* a reason for primary amputation. If gangrene has already set in, amputation is, of course, indicated.

Nerve Injuries.—Injuries to the nerves occur in fractures of the elbow as well as in dislocations, and may occur as a coincident result of the trauma, as the result of pressure of the fragments, or as a result of manipulation in reduction.

It is because of this last possibility that we should make it an *absolute* rule to test the function of *all nerves* before attempting to treat an injury in this region.

Median, musculospiral, and ulnar nerves are all subject to injury at this point. More especially the ulnar is liable to injury. Musculospiral injuries belong more particularly to fractures several inches above the joint, where the nerve winds about the humerus.

Ulnar nerve injuries are not uncommon in connection either with fractures of the internal epicondyle or with supracondylar fractures; they are shown by pain and loss of sensation in the regions supplied by the ulnar nerve. There is also apt to be some loss of motor power, to be found by the familiar test of the function of the interossei and of the flexor ulnaris.

As a rule, unless the disturbance is very severe, it is wise to wait in these cases. In all the instances in which the writer has waited there has been complete restoration of function within two to four months, showing that the nerve was only contused; in the one case of total *musculospiral* paralysis from elbow fracture* the same course was followed with the same result, though the period required for complete restoration of function was nearly two years.

Treatment †

Supracondylar fractures, if the displacement is backward, are reduced much as one reduces a backward displacement, and always, if possible, under an anesthetic. This one manœuver reduces the *backward* displacement, but does not secure correct position as to *lateral* displacement or rotation.

These lesions must be dealt with according to the case, and the fragment must be directly *shoved* into the best possible position. The restoration of the landmarks (olecranon and condyles) to their proper relation to the line of the humeral shaft is our only guide. The tendency is to let the forearm and the lower fragment drop or roll *too far inward*—this must be borne in mind. Overcorrection outward is usually impossible, owing to periosteal resistance.

* Operation refused. † Cf. Coenen, Beiträge z. klin. Chir., 1909, lxi, No. 3.

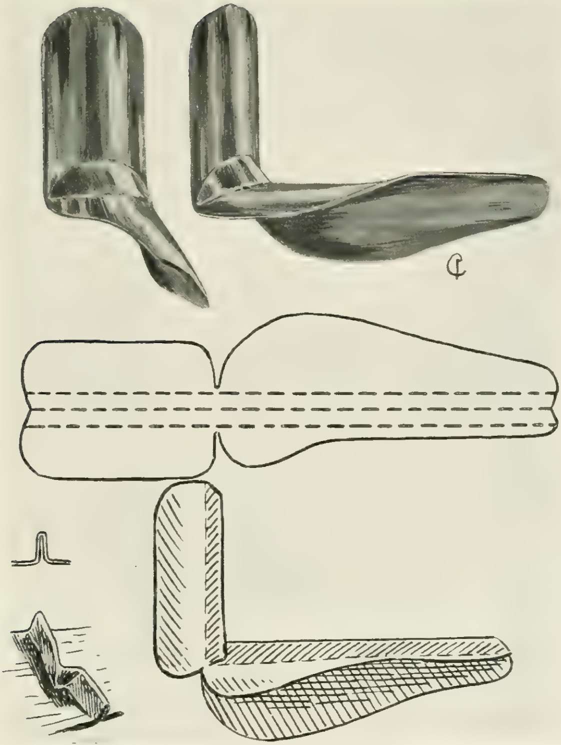


Fig. 314.—Internal angular splint, Bolles type. The lower figures show the pattern and the making of such a splint out of heavy tin. This splint shows an obliquity down and inward. (See Fig. 315.)

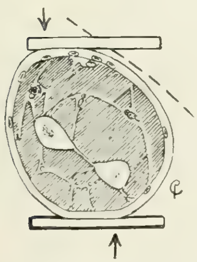


Fig. 315.—Cross-section of forearm below the elbow. The splints sketched (with the arrows showing the direction of pressure) show that there is a definite tendency to press the ulna up, the radius down. Only with an *oblique* splint, lying as shown by the dotted line, can we avoid this tendency.

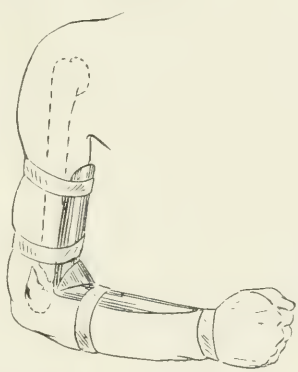


Fig. 316.—Internal angular splint. Shows the straps needed with the splint, to secure immobilization.

Fig. 317.—Position of supination, showing the carrying angle. The attitude shown in black line shows the position of pronation, with physiological disappearance of the carrying angle.

Fig. 318.—Proper application of sling: first stage.

Fig. 319.—Second stage: folded across in front over *opposite* side of neck.

After reduction seems complete it is well to grip the upper arm near the elbow in both hands with some force, so as to fix the fragments, then to let an assistant partly extend the arm; this will show whether the long axis of the arm has been approximately restored.

The splint to be used is the "internal angular," preferably of the "Bolles" type (Fig. 314). This is padded and is set close into the bend of the elbow, and strapped with adhesive to the upper arm; then, while some traction is exerted on the forearm to overcome possible backward displacement of the fragment, the forearm straps are applied. If the position is satisfactory, this will suffice; if there is any tendency to inward displacement, the addition of an *internal* coaptation splint is wise. (See Fig. 333.)

Fig. 320.—Third stage, completed. Note how the end from behind the elbow is carried forward and pinned, to make a secure pocket for the elbow.

Fig. 321.—*Wrong* way to apply a sling (though the usual way), letting the front corner go up on the same side instead of crossed. Gives a much less *secure* support.

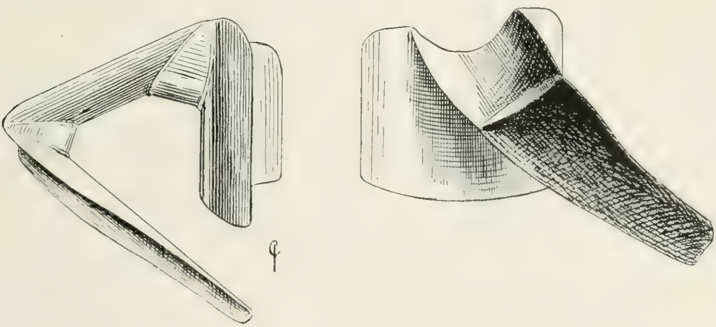


Fig. 322.—Osgood-Penhallow splint for right arm, seen from in front and from the right side.

Fractures lying well above the joint, and even those of the lower supracondylar type in adults, which show sharp *forward* displacement, are often best held on the Osgood-Penhallow splint,* in which the weight of the arm exerts traction and the splint gives counterpressure. (See Figs. 322–325.)

* Described in the Jour. Amer. Med. Assoc., July 31, 1909, liii, p. 375.

Very rarely weight traction may be called for. (See Fig. 233.) Acute flexion has been recommended for this as for other elbow

Fig. 323. Osgood-Penhallow splint "tried on." This shows the relations, but without padding.

fractures. It works well in some cases; in others it tends to produce forward rotation. In the cases shown (Figs. 330, 332) acute flexion was

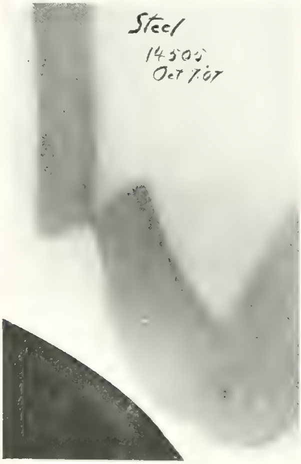


Fig. 324.—Case of high supracondylar break: position after treatment in acute flexion.

Fig. 325. Same case properly treated. Note how, on this Osgood-Penhallow splint, *both* overlap and bend are corrected.

the only and obvious cause of displacement. One of these cases came to open operation for correction, one to simple forcible correction.

The treatment on a straight splint has been much advocated. No doubt this is the *easiest* way to preserve the straight long axis of the

Fig. 326.—Adhesive strap applied to secure acute flexion, *properly* applied. The strap is laid flat on the skin; the ends meet at an angle and are pinned as well as stuck together.

Fig. 327.—The same strap *wrongly* applied as a circular band Symmetry is attained. but at the expense of a sharp constriction of the flesh by the upper edge of the strap.

arm and to avoid "gun-stock" deformity, but personally I have never found myself able to use it without *increasing the backward displacement*,

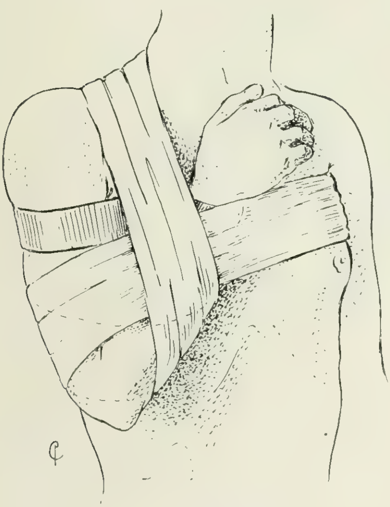


Fig. 328

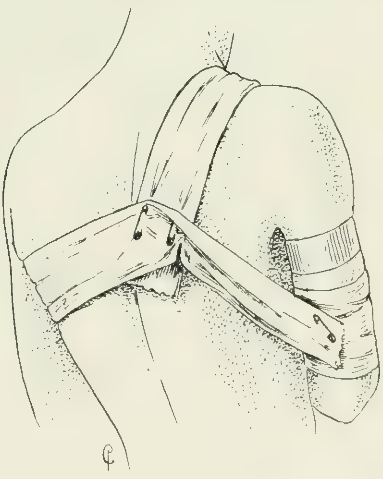


Fig. 329

Figs. 328, 329.—Front and back views of the "Lund swathe," author's modification. This is a figure-of-8, one loop going around the elbow (over the adhesive shown in Fig. 326), the other loop going over the neck and through the opposite axilla. From the meeting-point of the ends at the back a loose end is carried over to the loop about the elbow and pinned. The swathe is made of folded muslin cloth.

which is a much more serious matter than a slight "gun-stock." This consideration is entirely apart from the practical inconvenience of the

position, and the awkwardness of a possible total or partial ankylosis at or near the useless position of full extension.

T-fractures.—These are to be treated much as are the supracondylars, save that in case of much displacement of the shaft downward,

Fig. 330.—Supracondylar fracture treated in acute flexion. This fracture should not be treated in this position. Note the deformity both of angle and of overlapping.

Fig. 331.—Same case properly put up on an internal angular splint. Position not good, but much improved.

traction downward on the forearm, held at a right angle, will help clear the upper fragment out of the way and permit approximation of the condyles by manipulation. When the broken condyles are brought together, an effort may be made to impact them by lateral pressure.

In putting up these cases the same splints are usually used as with

Fig. 332.—A, Supracondylar fracture put up at a right angle; B, same case put up in acute flexion Courtesy of Dr. L. R. G. Crandon (outlines reinforced).

supracondylar fractures, but the addition of pressure pads, held in by adhesive straps so placed as to press the condyles together, is of great service. Occasionally splints to hold these pads (Fig. 334) are useful.

Fractures of the external or of the internal condyle present no problem of maintenance of relation between humerus and forearm, as

a rule. It is simply a question of the reduction of a *fragment* to its proper place. To some extent manipulation and rotation of the forearm may help in reduction (the ligaments between fragment and forearm being intact). In the main, however, it is a question of *direct manipulation* to correct *ascertained displacement.*

The form of retentive apparatus of most use depends on the individual case. Once reduction is satisfactory, we can directly test to determine the position that permits least mobility of the fragment. It may be the right angle, or at times a somewhat more open angle; often acute flexion seems to work best.* It is for us to choose the position for the individual case and to apply either the right-angled or an obtuse-

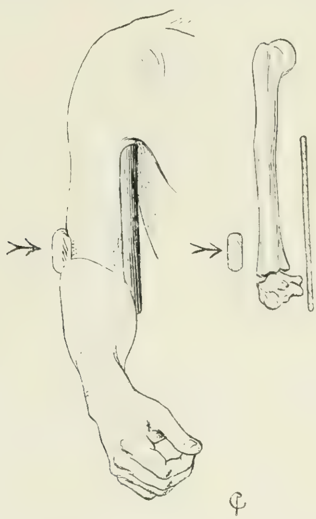


Fig. 333.—Prevention of rotation of lower fragment inward (this rotation is the cause of "gun-stock" deformity). A special strip of splint-wood runs from axilla to below the elbow, and on the outside a solid pad presses in just above the fracture.

angled splint, perhaps with special pads to drive the condyles home, or to apply acute flexion, according to the conditions found in the individual case.

* H. L. Smith showed very clearly years ago that acute flexion tends to fix fragments at the elbow by increasing the tension of the triceps and of its tendinous expansions. The position of acute flexion is, for various reasons, less universally serviceable in elbow fractures than he thought, but it is often very useful. (Boston M. and S. Jour., 1894, cxxxi, 386.)

R. Jones, of Liverpool, has also advocated acute flexion; his apparatus is decoyingly simple. It is shown in Fig. 335. (Provincial M. J., 1895; Arch. Pediatrics, 1892, ix, 435.)

F. B. Lund, Boston City Hospital Reports, 1897, p. 389, has devised the best bandage for maintaining acute flexion, but it is best used modified as in Figs. 328, 329, with the adhesive band shown in Fig. 326. Fig. 327 shows the not unusual *wrong* way to apply this adhesive plaster band, a way calculated to cause stoppage of circulation as well as cutting of the skin by the edge of the plasters.

Efficient use of acute flexion is possible only where great swelling has not yet taken place.

Internal Epicondyle. In these fractures we have no joint involvements, but we do have a muscle pull to deal with—we must relax the

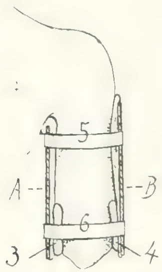


Fig. 334.—Lateral splints and pads held with straps to produce and maintain approximation of fragments in T-fracture. Seen from behind.

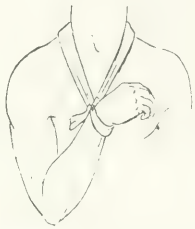


Fig. 335.—R. Jones's wrist-sling; a crude but efficient method of maintaining acute flexion of the elbow.

Fig. 336.—Acute flexion, with adhesive plaster as applied to separation or fracture of the internal epicondyle. A pad of felt or cotton is strapped in place with adhesive to hold the fragment back in place.

superficial flexors. The only position that will do this is full flexion, and I have no hesitation in recommending acute flexion for these cases.

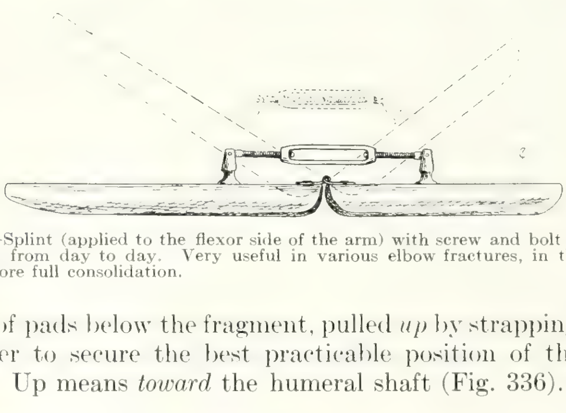


Fig. 337.—Splint (applied to the flexor side of the arm) with screw and bolt arrangement to vary the angle from day to day. Very useful in various elbow fractures, in the convalescent stage, even before full consolidation.

By means of pads below the fragment, pulled *up* by strapping, we can go even further to secure the best practicable position of the displaced fragment. Up means *toward* the humeral shaft (Fig. 336).

Results

In adults the result of these as of other joint fractures depends in part on the accuracy of reposition, but more particularly on avoidance of the loss of motion due to the trauma *plus* the fixation enforced to insure proper union. There must always be a compromise between the risk of deformity and the risk of loss of motion from overmuch and overlong fixation. In the past we have gone too far in the direction of long fixation in such cases. Lucas-Championnière and his followers have probably gone too far in early mobilization. Yet under favorable circumstances, with a "good" patient, very early mobilization shows

excellent results. So soon as the first tenderness and swelling begin to subside, or even before this, say at fourteen days, in many cases even as early as ten days, and in all simple fractures within three weeks, *careful* massage is in order. Very gentle *passive* motion may be begun, at the same time, with manual fixation of the fragments. This is early to be supplemented by *active* motion carried out by the patient at regular times daily. For these exercises, all dressings are removed.

Forced passive motion is rarely to be recommended, for its tendency is to "stir up" the joint, and so to stiffen it, instead of limbering it. This does not mean, of course, that forcible rupture of adhesions *under*

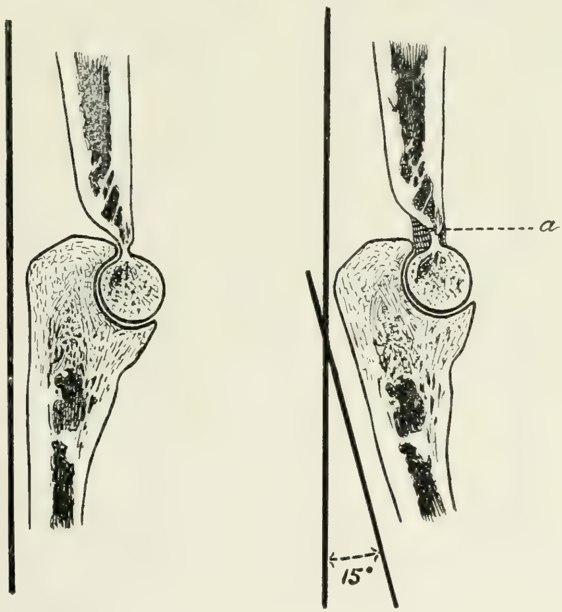


Fig. 338.—Diagram to show the amount of the limitation of extension that may be caused by very moderate callus (*a*) in the olecranon fossa, without displacement of fragments (median section of dry bones).

ether may not be necessary at a later stage. In fact, however, this measure is rarely called for.

Active motion, even with courageous and persistent patients, is rarely pushed beyond the point of slight pain. It is as efficient as passive motion in limbering up muscles and joints, and is practically free from the chance of increasing joint irritation.

After three, or at most four, weeks, splints may be laid aside and a simple rest-sling used for a fortnight. The older treatment (four to six weeks of absolute fixation) is disastrous, and may be avoided in all save perhaps in some severe *compound* fractures.

Results in the adult are largely dependent on the possibility of

carrying out this somewhat difficult routine of after-treatment. If this treatment has been carried out, we have only the deformity and limitation of motion due to displacement of bone, and the deformity from callus. This is an ideal condition, and by no means always attainable, whether on account of circumstances, or because of lack of interest, courage, or persistency on the part of the patient.

As to disability and deformity, due to displacement, we are apt to have the following conditions present in greater or less degree.

In supracondylar fractures and in the T-fractures without great displacement we get a varying valgus or varus deformity (details considered later under the children's fractures), some limitation of flexion from displacement of the upper fragment forward, some limitation of extension from filling up of the olecranon fossa by callus. (See Fig. 338.)

These are approximately *permanent* results; with careful work, however, the end-result is fair, as a rule. Bad results usually come from grossly bad position or from over-long fixation.

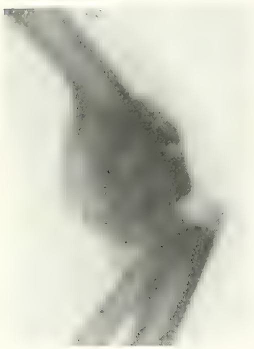


Fig. 339.—Fracture of condyles and fracture of shaft above condyles from two *separate* injuries.
Result poor: excessive callus formation. Elderly patient with arthritis deformans.

Bad T-fractures may be impossible to hold in place, and the results may be almost necessarily bad; we may even have complete ankylosis. Many of these cases when compound, and even some of the simpler T-fractures, come to joint resection later, but enough of them do well to make *early resection unjustifiable.*

Fractures of the external condyle do well, as a rule. Very rarely non-union results. There may be some broadening and thickening at the outer part of the bone. Other *deformities* do not occur. Some *limitation of motion* is apt to be present, due mainly to callus in the olecranon and coronoid fossæ, but a useful arm may be expected.

Fractures of the internal condyle are even more apt to have limitation of motion for the same reasons, but the functional result is usually good under adequate treatment.

Internal epicondylar fractures often unite by fibrous tissue only, but the union is firm, and save for some slight loss of power in the fore-arm flexors, eventually recovered from, no ill results ensue.*

Pathologic Fractures.—Under this caption may be classed certain *re*fractures, including cases in which previous partial ankyloses have determined the fresh fracture. I have seen one case (apparently an

* *A priori* one would expect some *late* trouble with the ulnar nerve resulting from the fibrous union with displacement of the bone fragment, but this does not seem to happen.

osteogenesis imperfecta; he had had various other fractures from slight trauma) in which there had been a condylar followed by a supracondylar break. Fig. 339 shows a like unfortunate result, in this case a fracture near an arthritic joint. Such cases are important in that good results are hardly to be expected. I have seen two cases in which poor results from old supracondylar lesions apparently acted as determining causes of fresh *olecranon* fracture.

FRACTURES OF THE HUMERUS AT THE ELBOW IN CHILDREN

Anatomy of the Epiphyses.—The differing shape and growth of the

Fig. 340.—Epiphyses in the new-born. Displacement backward.

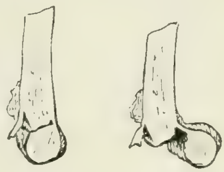


Fig. 341.—Epiphyses in the new-born. Displacement forward.

Fig. 342.—Epiphyses at eight years (drawn from Warren Museum, specimen 334).

epiphyses must constantly be borne in mind in examining children's fractures. At birth, and up to two or three years of age, the whole lower end of the humerus is a cartilaginous mass in which an ossification center appears at

Fig. 343.—Epiphyses at eight years.

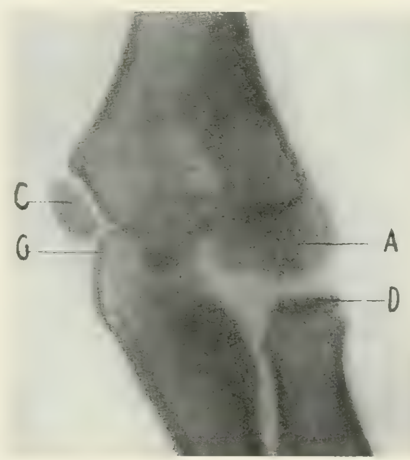


Fig. 344.—Epiphysis at ten and one-half years. Anteroposterior view: *A*, Capitellar epiphysis; *C*, epitrochlear epiphysis; *D*, radial epiphysis; *G*, trochlear epiphysis.

the outer side at about one and one-half to two years of age.

Injuries up to the age of three or four years must almost necessarily

be a separation of the epiphysis *as a whole.* By four or five years of age the external condyle has become a definite structure, and a cleavage line in the cartilage has been formed. (See Figs. 342 and 343.) The internal epicondyle shows a bone center at about five years, and at about ten to twelve years it has been separated from the rest of the epiphysis by the growth of the shaft downward into the epiphysis, leaving only a shell of epiphysis over the trochlear surface, with a small ossification center. From this time onward growth occurs by progressive ossification of the external condyle and by growth of the diaphysis downward.

Fig. 345.—Epiphyses at ten and one-half years (B. C. H., plate 880).

The external condyle unites to the shaft usually between sixteen and nineteen years of age, but may persist longer.

From an early age the line of demarcation of the external condyle includes not only the capitellum, but also the *outer edge of the trochlear articular surface.* This demarcation persists,

Fig. 346.—Epiphyses at ten years (Warren Museum specimen (no number), seen from front and from outer side).

Fig. 347.—Same specimen as Fig. 346, seen from the back.

although after about fourteen years there is only a very thin layer of epiphyseal cartilage marking this line (Figs. 343–348).

Fig. 348.—Epiphyses at fifteen years (Warren Museum, specimen 537).

Fig. 349.—Epiphyses at eighteen years (Warren Museum, specimen 417). From behind. Shows only the internal epicondyle still separate.

There is an ossification center of the external *epi*condyle appearing at twelve to fourteen years, fusing, as a rule, with the external condyle

by the sixteenth year. It is never more than a scale, and is surgically unimportant.

Growth on the *inner* side—growth of the trochlea—is by growth of the shaft down into the epiphysis, and the lower end of the ossified shaft becomes very oblique as time goes on (Figs. 343, 344).

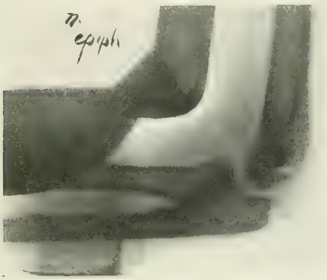


Fig. 350.—Epiphyses at ten years. Lateral view. Note how far forward the epiphysis of the external condyle lies in relation to the shaft and also how much of the olecranon is still cartilaginous.

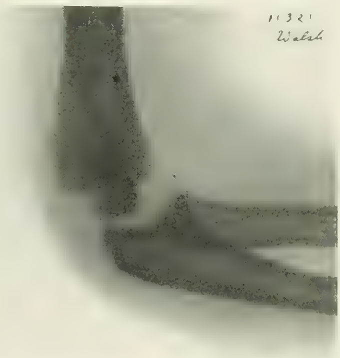


Fig. 351.—Epiphyses at eight years. Same case as Fig. 343. Lateral view, slightly distorted.

There is sometimes, at about thirteen years of age, a small ossification point in the trochlear portion, visible in the skiagraph, but this separate epiphysis has long before this become very thin, and is fused with the shaft soon after this. Surgically, it is of little consequence. It is the exception for it to be visible in x-ray plates at *any* age.

The last epiphysis to unite is that of the internal epicondyle. It may join as early as sixteen to eighteen years, but often there is delay and, according to Rambaud and Renault,* it may remain as an epiphysis through life.

In regard to judging the relations of epiphyses in x-ray pictures (a very difficult matter in many cases), it may be well to bear in mind the following points:

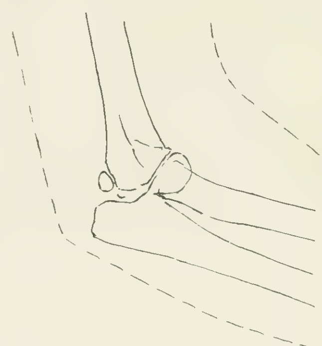


Fig. 352.—Tracing of x-ray of normal elbow. Shows how confusing a slightly oblique x-ray view of a normal elbow may be.

(1) That the capitellar epiphysis is, in the lateral view, projected against the lower inner end of the diaphysis, because it lies higher, and that it normally lies well *forward* of the axis of the shaft.

* Developpement des Os, 1864, quoted by Poland.

(2) That there is *normally* a marked apparent gap representing the space actually filled by the articular cartilage of trochlea and ulna.

Fig. 353.—The commoner forms of lesion at the elbow in children, according to Judet (sketched from his published plate).

(3) That the trochlear epiphysis is not always apparent, even when we might expect ossification to be present in it: it is, in fact, rarely seen.

(4) That the center of ossification of the epitrochlea is thin and may not show even in the anteroposterior view.

(5) That this same epiphysis *may* show in the lateral view and give rise to confusion if its identity is not suspected.

(6) That the ossification-center of the epiphysis of the external *epi*condyle is so small and so unconstant that it may practically be disregarded.*

(7) The obliquity down and inward of the lower end of the diaphysis, as seen in the x-ray, is constant, and increases with growth.

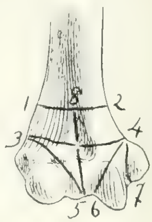


Fig. 354.—Typical fracture lines according to the writer. The T-fractures, and the fracture along line 4–6, almost never occur in children. The children's types are: (*a*) The supracondylar, 1–2, 3–4, or at the epiphyseal line; (*b*) the external condyle, 3–5; (*c*) the internal epicondyle, 4–7.

Classification of Fractures of the Humerus at the Elbow in Children.—The fractures and separations which do, in fact, occur in children are: Supracondylar fractures; separations of the whole epiphysis; separations of the external condyle; separation of the internal epicondyle.† In all except the first type these separations follow more or less closely the epiphyseal lines. The supracondylar fractures are in all respects like those we have considered in the adult, save for the greater stripping-up of periosteum, and the *diagnosis* of this lesion is no way different in children.

Supracondylar Fracture in Children

No fracture at the elbow is more familiar; whether this or the external condylar fracture is more often met with is a question differently answered by different statistics.

This lesion differs in no essential from the corresponding injury in the adult either in mechanism or in lesions.

* The foregoing is quoted practically verbatim from Cotton, "Elbow Fractures in Children," Ann. Surg., February, 1902.

† Judet (Arch. d'éléctr. Méd. Bordeaux, 1906, xiv, 123–141) has a discriminating article, primarily on supracondylar fractures in children, but dealing also with the classification.

Not uncommonly lack of anatomic knowledge seems to lie at the back of some classifications. For example, a recent article by Warbasse (Med. Record, January 30, 1909, p. 170) figures as epiphyseal lesions a number of cases that the x-rays seem to show clearly as *supracondylar* fractures.

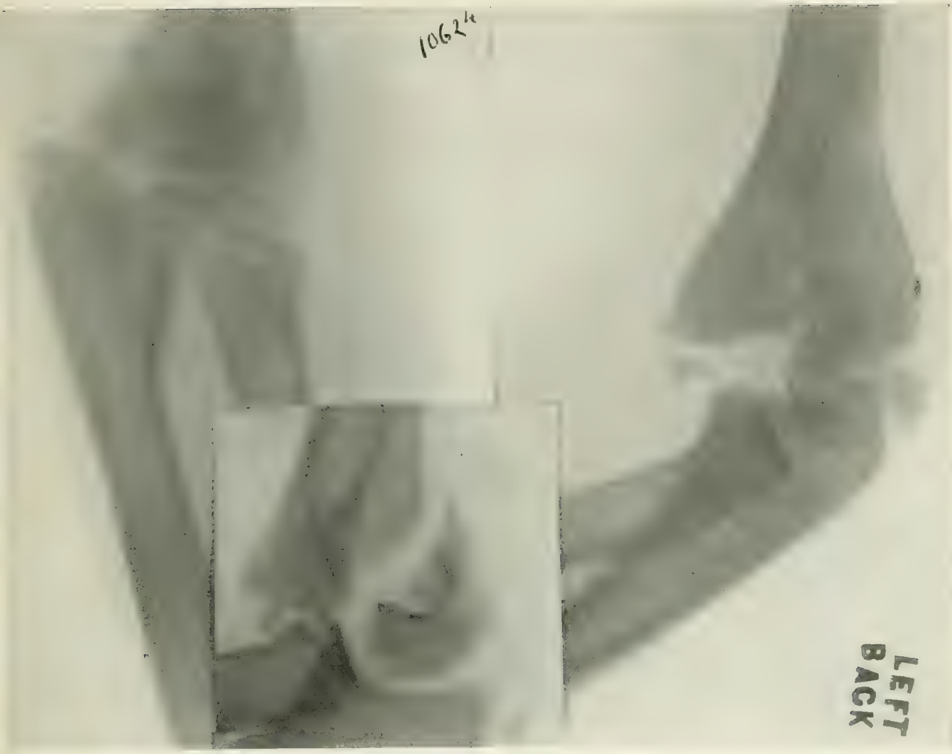


Fig. 355.—*X*-rays (after one year) of a case of separation of the whole lower epiphysis of the humerus, with a chip of the shaft also torn away on the outer side. Boy of twelve years.

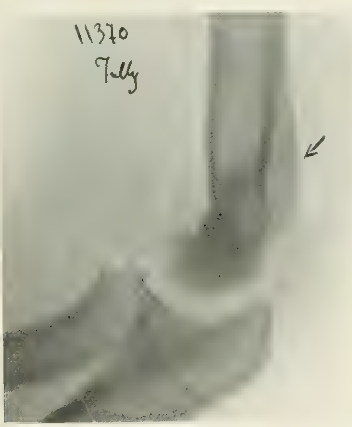


Fig. 356.—Supracondylar fracture; no displacement, but a good deal of disability. The arrow shows the line of fracture, evidently a subperiosteal fracture.

Fig. 357.—Boy of nine years, supracondylar fracture, backward displacement, rotation of shaft forward on the inner side.

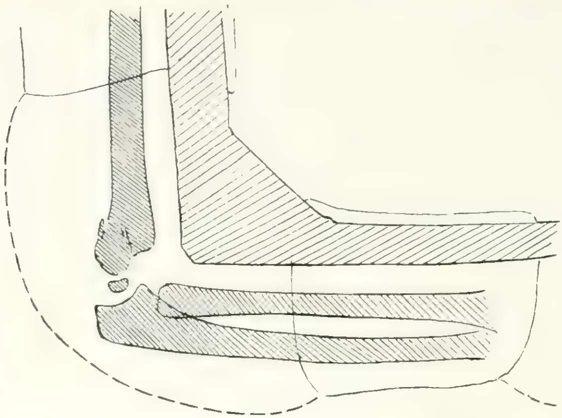


Fig. 358.—Supracondylar fracture with moderate backward displacement (tracing of x-ray plate).

Fig. 359. Supracondylar fracture: extreme stripping-up of periosteum from shaft.

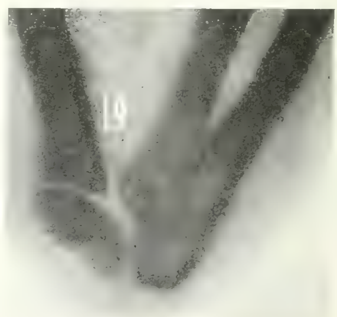


Fig. 360. Girl of three years. Supracondylar fracture, acute flexion.

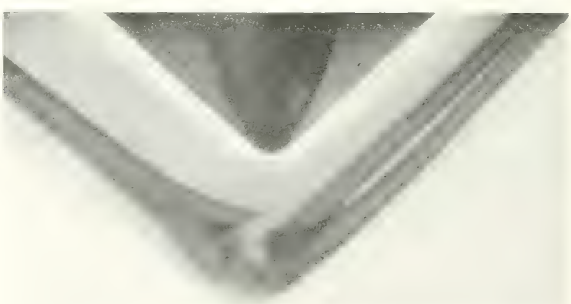


Fig. 361.—Age nine years; supracondylar fracture with rotation.

As a rule, we meet with fracture of the "extension" type, oblique up and backward, displaced up and backward. Forward displacement occurs, but is rare; forward *rotation* may be primary, but more often results from unwise treatment.

As a rule, there is a rotatory displacement about the vertical axis. Probably this results from the action of the strong outward rotators at the shoulder, now unopposed by the inertia of the forearm; at all events we commonly find the upper fragment rotated forward and inward, a point of great importance, as we shall see later.

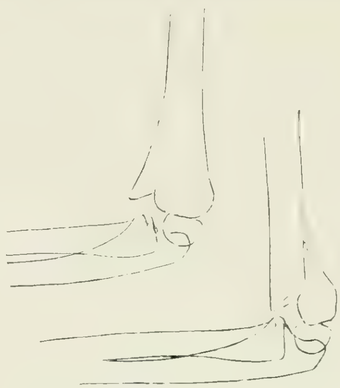


Fig. 362.—Supracondylar fracture with displacement. Seen before and after attempted correction.

In the supracondylar fractures in children there is apt to be extensive stripping-up of the periosteum at the back, but this does not commonly interfere with reduction, and with proper reduction it does not affect the results appreciably. Rarely, we may find incomplete (or greenstick) fracture at this point.

The usual site of the break is low, above the epiphyseal line but only just above it, running, as a rule, obliquely, but not very obliquely, up and backward.

Fig. 363.—Supracondylar fracture. Tolerably good position, but there is likely to be loss of flexion from the coronoid hitting the spur seen above it.

Fig. 364.—Supracondylar fracture in a child of six. The upper plate shows the spur (due to *rotation* of the shaft *outward*), which is apt to check flexion. The lower shows the displacement and rotation *inward* of the axis of the forearm, sure to give gun-stock deformity.

The displacement is dependent on the original trauma; the rotation

Fig. 365.—Supracondylar fracture. Marked displacement of lower fragment inward.

Fig. 366.—Same case as Fig. 365. Shows extreme backward displacement. This was an old fracture, later operated on; good result.

of the fragment depends on later handling; in a general way the lower fragment of the humerus follows the movements of the forearm.

Supracondylar fractures in children show, as a rule, a marked swell-

Fig. 367.—Supracondylar fracture. Good reduction.

Fig. 368.—Supracondylar fracture with extreme backward displacement (before reduction).

Fig. 369. — Supracondylar fracture with great backward displacement.

ing, much ecchymosis, occasionally blebs—far more reaction than is usual in fractures of other types in this region in children.

Separation of the Whole Epiphysis

Separation of the *whole* epiphysis is possible up to four years of age. After this, separation of this sort at least does not involve the internal epicondyle; in fact, it is rare after this age in any form. The mechanism of the lesion seems to be the same as in the supracondylar cases.

Fig. 370.—Supracondylar fracture; the lower fragment, with the forearm, is much displaced *back* and *outward*, and is rotated *outward*, as well, on the axis of the humerus.

Except in very young children, in whom there is occasionally a loosening of the epiphysis *laterally*, the displacement is just like that of fracture above the condyles, from which it is not always easily distinguished save with the aid of the *x*-ray.

Neither in displacement nor in rotation does this lesion differ from the supracondylar fracture nor is it differently treated.

There is a definite tendency for these epiphyseal separations to be compound,—the wound (of emergence of the shaft) lying on the *front* of the elbow.

Ordinarily, the epiphysis is separated without splitting, so far as we know, but the *x*-ray can hardly decide this point, and I have repeatedly seen cases where I was in doubt.

The specimen shown in Fig. 386 shows that such splitting may occur. Such splitting of a separated epiphysis is the only form of T-fracture in childhood that seems established by actual evidence.

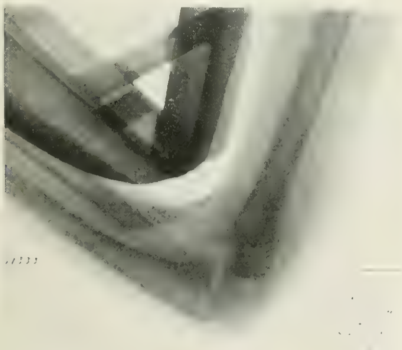


Fig. 371.—Supracondylar fracture. Fair reduction: 1, Shaft of humerus; 2, lower fragment of the shaft; 3, epiphysis continuous with 2; 4, new bone under the stripped-up periosteum behind.

Fig. 372.—Supracondylar fracture. Good position, but with slight *forward* displacement, from overreduction.

18

Interference with growth from damage to the epiphyseal line in these cases is at worst rather rare. One still reads at times articles by men who have no cases to record, but believe such interference with growth something usual and much to be dreaded.*

Separation of the External Condyle

Separation of the external condyle is about as common an accident as the supracondylar lesion.

In very young children the separation follows exactly the cleavage line of the external condyle cartilage (see Figs. 343 to 351), a line running *beyond* the condyle in the joint, taking in the external edge of the trochlea as well.

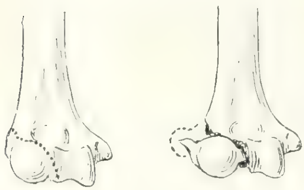


Fig. 373.—To the left is shown the line of fracture, including the outer edge of the trochlear articular surface, running along the epiphyseal line, then up and out above the external condyle, tearing away a bit of the diaphysis. In the figure to the right is shown the way in which the fragment often rotates, throwing the fragment of shaft outward. The resultant new-growth of bone is indicated in dotted line. This is what I have called the external condyle "spur."

Fig. 374.—Sketch from negative showing fracture line; poor negative.

In the older children the line within the joint is the same, but at the upper outer corner we are apt to find a chip of the shaft torn loose *with* the epiphysis. (See Fig. 373, 378, 379.)

The fragment separated is still united to the radius by ligaments. Its *displacement* is apt to be very slight, but *rotation* down, outward, and often forward, is apt to occur.

The diagnosis is to be made, as in the adult, by the evident limitation of injury to the outer side of the joint, and by the mobility of the separate fragment.

Crepitus is often not obtainable.

Lateral mobility of the forearm as a whole does *not* occur, a point definitely distinguishing this lesion from the first two classes.

Separation of the Internal Epicondyle

This is an accident involving less severe trauma than the other lesions, a trauma evidently due, sometimes to a direct blow, rarely to the pull of the muscles which arise from this process. In the latter case, displacement must be down and forward (see Fig. 381); in the former it may be forward or rarely upward. (See Fig. 382.) As a rule, the separation is clean through the epiphyseal line. At the age when it does, in fact, occur (*i. e.*, after ten years) the joint is very rarely opened by avulsion of this process.

* The most recent noted is by Warbasse, Med. Record, January 30, 1909, p. 170.

Associated damage is apt to be slight; ecchymosis and tenderness are local.

The above applies to the simple cases without other damage. The cases in which this lesion is but a detail (though an important one) of elbow luxation have already been considered.

T-Fractures

T-fractures occur so rarely in children as to be almost negligible.

There are a few well-attested cases where the epiphysis is split through, substantially without separation of the fragments. (See Fig. 386.)

The elasticity of the cartilage, and the presence of a line of less re-

Fig. 375.—Fracture of the external condyle on the left side. Photographed directly after injury.

Fig. 376.—Skiagraph of case of separation of external condylar epiphysis.

sistance along the line of external condyle fractures, are the probable explanation not only of the non-occurrence of T-fracture, but also of the fact that a fracture of the internal condyle into the joint occurs very rarely, indeed, in childhood—so rarely as hardly to deserve a place in our classification.*

* It is only fair to say that, apart from Mouchet (*loc. cit.*) and a more recent article by Judet (Arch. d'électr. méd., Bordeaux, 1906, vol. xiv, pp. 123–141), my classification above given has not been generally agreed to. As I see more and more cases, however, I am more inclined to insist on it.

Diagnosis

Supracondylar fractures give definite displacement (almost always backward), differing from other lesions in that the forearm and both condyles move back *together*, with their mutual relations undisturbed.

There is often crepitus.

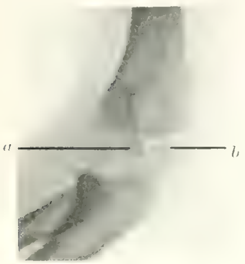


Fig. 377.—Epiphyses at three years: *a*, Capitellar epiphysis; *b*, fragment of periosteum; case of (reduced) separation of the external condyle.

There is free abnormal mobility *laterally*, present *only* in the *supracondylar* lesions.

Flexion is apt to be limited. Extension is free, but extension gives increase in the deformity.

Separation of the whole epiphysis, occurring in very young children, differs in no way, clinically, from the supracondylar lesions, except that crepitus is "soft." The final decision may depend on the *x*-ray. Between these two forms of lesion *exact* diagnosis is of no real consequence.

In *external condyle fractures* we have damage obviously mainly confined to the outer side of the joint. There is no deformity of the general axis of the arm. There is a movable external condyle, movable apart from the shaft of the humerus. False motion of the joint is little, and usually consists of a little abnormal motion in *ab*duction.

As to the position (rotation, etc.) of the fragment itself, we can tell nothing until we get the *x*-ray picture.

Separation of the internal epicondyle is diagnosed by—(*a*) intact (passive) mechanism of the joint; (*b*) lack of lateral play in the joint; (*c*) local tenderness and swelling; (*d*) thickening at a point near, usually below, the proper site of the

Fig. 378. Separation of external condyle epiphysis with a chip of the shaft at the outer side (lateral view).

Fig. 379.—Separation of external condyle (and probably of whole epiphysis) with a chip of the shaft at the outer side (child of four).

epicondyle; (*e*) sometimes a loose fragment can be made out; (*f*) pain on active use or on passive stretching of the superficial flexors of the arm.

As a rule, the diagnosis is actually based upon the change in shape of

Fig. 380.—Separation of external condyle with displacement out and *up* (sketched according to the findings in a clinical case).

Fig. 381.—Typical displacement, *downward*, of the separated internal epicondyle.

Fig. 382.—Displacement of the epicondyle *upward*. This is very rare—I have seen it but twice.

the portion of bone left behind, with the disappearance of the "hook," and the changed relation of the ulnar nerve.

T-*fracture* and *fracture of the internal condyle*, if they occur, give something near the signs of like lesions in the adult.

The best guide as to the success of reposition is palpation. Remember that the external

Fig. 383.—*X*-ray tracing

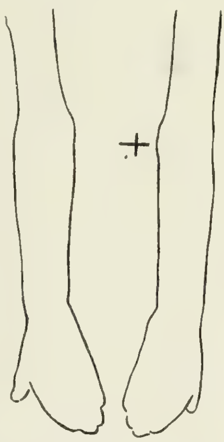


Fig. 384.—Separation of internal epicondyle. Tracing of arm.

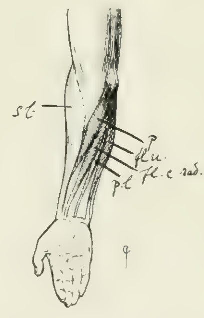


Fig. 385.—The muscles arising from the internal epicondyle (pronator radii teres, flexor ulnaris; flexor carpi radialis, palmaris longus). These show marked atrophy if the epicondyle is broken.

condyle should lie a little *higher* than the internal epicondyle, and the olecranon only slightly behind the condyles. We may, while holding the fragments firmly, partly extend the arm to test the axis.

There is a tendency to outward rotation of the shaft (by the shoulder rotators) that leads to deformity like that shown in Fig. 389. I know

no way to correct this except to carry the whole arm into outward rotation as we reduce, in this way entangling the fragments so that position is retained even after rotation inward.

Fractures of the *external* condyle are best reduced by pressure inward on the fragment, executed while various motions of the forearm are being carried out. In this way pressure combines with the pull on various ligaments to help slip the condyle in place.

If there is evident widening, then forcible jamming of the condyle against the shaft is wise; it may give impaction, though not firm impaction.

Correction of rotation of the fragment down and outward is desirable, but it is very difficult to be sure of this rotation—to say nothing of its correction—until x-ray pictures are taken. These fractures *usually* repair satisfactorily if put up either at right angles or in acute flexion. There seems no especial advantage in acute flexion.

Separation of the internal epicondyle is reduced by direct manipulation, by putting the arm up in acute flexion in a "Lund" swathe, and holding the fragment as near the shaft as possible by means of a pad and strap (Fig. 336).

In fractures and separations of this class in children no stress is laid on early mobilization. There is no tendency to permanent stiffness at this age, and fixation is the only important point after reduction has been done. Splints are not usually necessary more than about two and one-half weeks, or even less in very small children.

In fractures of the external condyle the writer never hesitates, however, to leave splints on for five weeks or more if there is any *question as to the union* of the condyle. Passive motion is not necessary in these fractures, and forced passive motion, once so much advocated, seems productive only of harm from joint irritation. If the child, after union is firm, is allowed to use the arm gently at first, he will in time develop all the motions permitted by the position of the fragments.

That is to say, *the result depends in children not at all upon the time of fixation*, but entirely upon the perfection of reduction and upon the absorption of callus.

This does not mean that there is any *prompt* restoration of motion. In a long series of these cases, followed up many months later,* the writer found astonishingly good results as to motion, but found that full motion was not regained until three to eight months after the removal of the splint. Many of these cases showed only a very small arc of motion at the time of their original discharge from treatment.

So far as displacement and deformity are concerned, there is a curious constancy about these cases. Supracondylar fractures and separations of the epiphyses usually show slight backward displacement in spite of good treatment, and they not uncommonly show a rotation

* Cotton: Ann. Surg., February, 1902.

of the lower fragment back under the broken internal condyle, or, more accurately, external rotation of the loosened *shaft*, in such fashion that flexion is checked by the coronoid process hitting the condyle (Figs. 389, 405, etc.). Extension is rarely interfered with, and is often possible beyond the normal limit. Deformity is often in the line of the so-called "gun-stock" deformity. This may be very extreme. It comes from the rotation in and upward of the lower fragment, changing the plane of the joint so that the forearm bones are extended sharply down and *inward*, as shown in Figs. 388, 400, etc. The existence of such deformity alone gives the diagnosis of a supracondylar lesion.

Fractures of the external condyle show, as a rule, no permanent loss of motion excepting that *hyper*extension of the elbow may not be possible.

They do not show any gun-stock deformity.

They uniformly show some alteration in outline of the outer side of the joint. (See tracings, Figs. 411 and 412.) At times there is a well-marked "spur" growth above the joint (Figs. 410, 411). This is a result of *growth* of the detached bone and of the periosteum, which is torn away with the epiphysis. It proves nothing as to position of the fragment, and is apparently unavoidable in many cases.

There may be some widening (up to ¼ inch), owing to displacement of the loosened condyle *outward*.

There is nothing to do about this rotation unless we can operate. In three such cases of short duration I have made the oblique posterior incision, freed the broken surfaces, corrected the rotation, not without much difficulty, and with sutures and a drill used as a peg (later removed) have fastened the fragment in place. A later x-ray showed practically perfect position. I am sure no great spur-formation will take place. Dr. J. S. Stone has also done several such operations with success, I understand.

Fig. 386.—T-fracture in a child. This resulted from direct crushing, a compound fracture. So rare a form of fracture in childhood as to be negligible (Warren Museum).

Treatment

The supracondylar fractures in children are treated exactly as in adults, so far as reduction is concerned. The internal angular splint will usually be found most serviceable. Cases where there is marked tendency toward backward displacement of the lower fragment *may* best be treated in acute flexion.

This is a matter of judgment, purely.

Treatment in the extended position never seems to be called for.

It gravely increases the chance of backward displacement of the condylar fragment, to say nothing of the inconvenience of the position and of the small chance of stiffening at this unhandy angle.

Fig. 387.—Supracondylar fracture (schematic).

Fig. 388.—Inward displacement and rotation of lower fragment and forearm, the cause of gun-stock deformity.

Fig. 389.—Supracondylar fracture: backward displacement. This backward displacement is usually combined with a rotation of the *shaft* outward that brings the broken end of the ridge that runs up from the internal condyle toward the front, where it is very likely to meet the coronoid process (shown by the arrow) (compare Figs. 359, 361, 362, 364, 370, 407).

Fig. 390.—Shows how extension may aggravate deformity; the fracture is a freer point of motion than the joint (especially if there is muscle spasm).

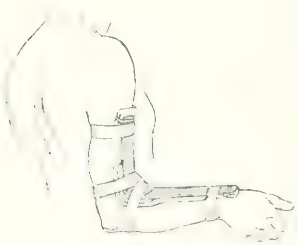


Fig. 391.—Internal angular splint—application. There should be a special pad at the bend of the elbow, general padding (three or four thicknesses of "sheet-wadding") fastened to the splint with adhesive. The splint is then fastened to the arm with four strips of adhesive 1 to $1\frac{1}{2}$ inches wide, placed as shown, two above, two below. Outside this comes a layer of sheet-wadding over all, then a bandage, and last of all the sling.

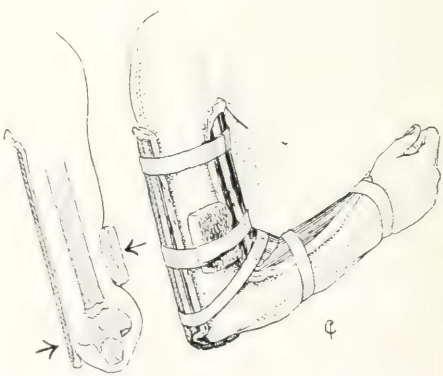


Fig. 392.—Internal coaptation splint used with the "internal angular" to insure against "gun-stock deformity" from inward displacement and rotation of the lower fragment

Fig. 393.—Increase of deformity due to acute flexion. Acute flexion acts by a tightening of the triceps tendon and its expansions about the fragments at the joint. This action depends on an intact humerus for counterpressure. If the humerus is broken across, the counterpressure fails, and flexion tends usually to produce shortening with displacement either forward or back.

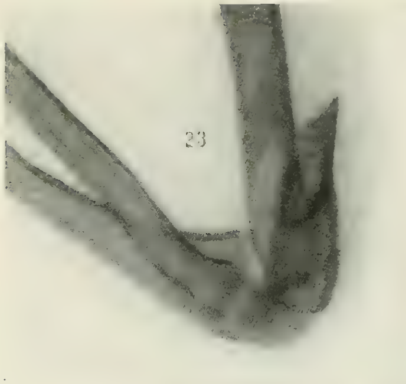


Fig. 394.—Acute flexion with consequent production of deformity.

Fig. 395.—Acute flexion applied (properly) to a case of separation of the internal epicondyle The displaced epiphysis does not show in the print.

The claim that it is a necessary procedure in order to preserve the long axis of the arm is fallacious.

It is true that in treating this fracture there is likely to be a deviation

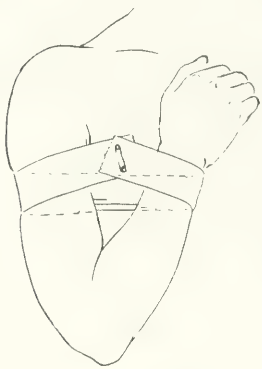


Fig. 396.—Acute flexion by means of an adhesive strap.

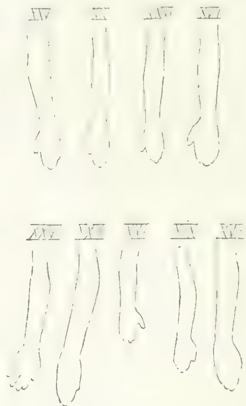


Fig. 397.—Tracings of end-results in supracondylar fracture (author's cases). XXV, XXIII, XIX, show gun-stock deformity (slight); XXVIII shows a trace; the others are good results.

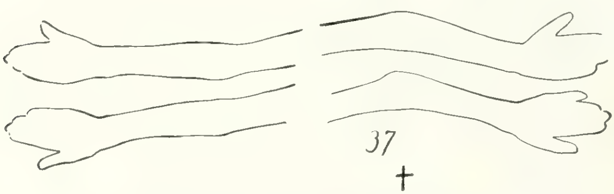


Fig. 398.—Gun-stock deformity, arm tracing.

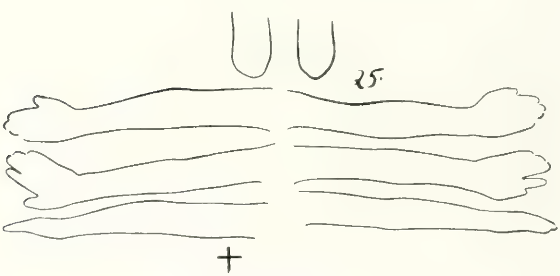


Fig. 399.—Arm tracings.

in the axis of the arm, and that the greatest care must be taken to avoid any dropping inward of the fragment toward the body. Such inward

Fig. 400.—Photograph of end-result in a case of supracondylar fracture. Marked "gun-stock deformity" of the right arm (this case was operated on later, with marked improvement resulting).

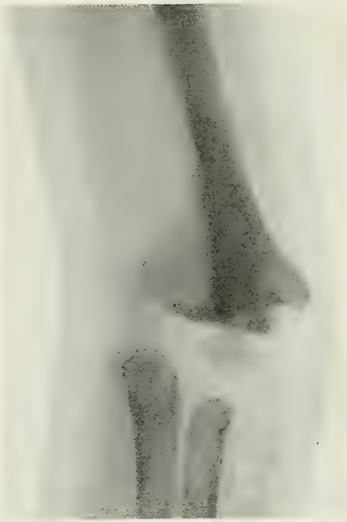


Fig. 401.—Gun-stock result, x-ray, anterior view.

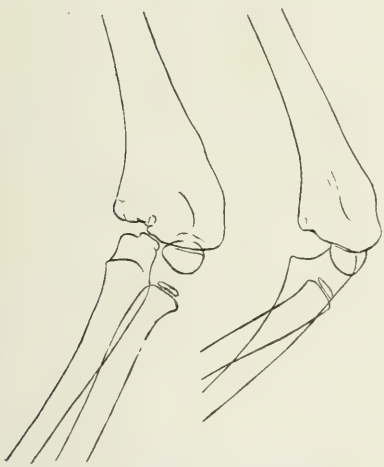


Fig. 402.—Extreme gun-stock deformity—old supracondylar fracture.

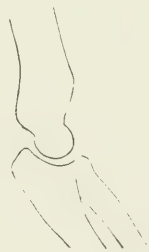


Fig. 403.—Backward displacement. End-result of supracondylar fracture (after Mouchet).

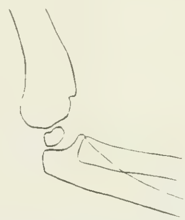


Fig. 404.—Backward displacement, after supracondylar fracture (after Mouchet).

deviation is the cause of the much-discussed gun-stock deformity.* Not infrequently, if this fact is borne in mind in reduction, the arm may

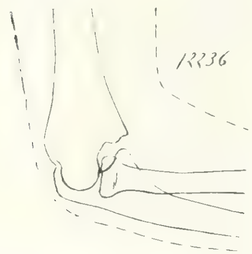


Fig. 405.—Backward displacement with check to flexion. Supracondylar fracture (same case as Fig. 400).

Fig. 406.—Gun-stock deformity after supracondylar fracture (same case as Figs. 400 and 405).

be so reduced and "locked" on the splint that the contact of the rough fragments will *prevent* any such deformity. In order to minimize any

Fig. 407.—Check to flexion. Supracondylar fracture (compare x-rays of same case, Fig. 355).

Fig. 408.—Extension in the same case; note that the elbow is away from the side, and the arm rotated so that the olecranon looks outward. This curious and confusing spiral movement of extension is seen in all cases with "gun-stock" deformity.

tendency of the splint to produce it, it is wise to use the oblique "Bolles"

* "Gun-stock" deformity is a result of supracondylar fracture, not of displacement of one or the other condyle. Allis, many years ago, and without precise data, alleged that it resulted from ascent or descent of *one* condyle, and his statement has been accepted and copied by many. Stimson, in this country, and several of the best Frenchmen, have recognized the facts. I stand to my opinion, expressed in the Annals of Surgery, February, 1902, that Allis was in error, and that such deviation belongs, with the rarest exceptions, to the lesions involving the full width of the humerus.

Fig. 409.—Fracture of external condyle. Shows the "spur" growth of new bone arising from the rotated bone fragment. (Compare Figs. 373 and 411, 412.)

Fig. 410.—Same case viewed from behind.

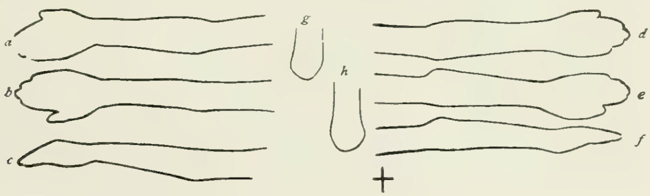


Fig. 411.—Arm tracings—right arm: *a*, In supination; *b*, in pronation; *c*, with ulnar side of hand down (on paper); *g*, upper arm laid on the table, elbow in full flexion. Left arm: *d*, supination; *e*, pronation; *f*, ulnar side down; *h*, upper arm, elbow flexed.

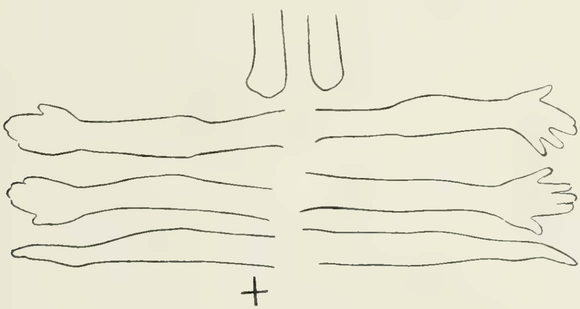


Fig. 412.—Arm tracings of external condyle fracture.

splint. (See Fig. 314.) The mechanism of this splint and the mechanism of production of the deformity by the ordinary splint may be understood from Figs. 315 and 316. A serviceable method of preventing deformity where the fragments are loose is the one (first orally suggested to me by C. A. Porter)* of the addition of a padded internal splint on the inside of the arm, supporting the lower fragment, as

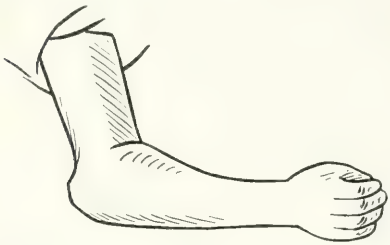


Fig. 413.—Deformity after union in a fracture of the external epicondyle (after Mouchet).

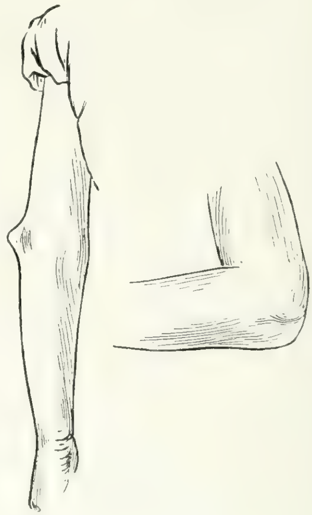


Fig. 414.—Ununited external condyle.

shown in the sketch. This scheme has proved very serviceable in certain cases.

Fig. 415.

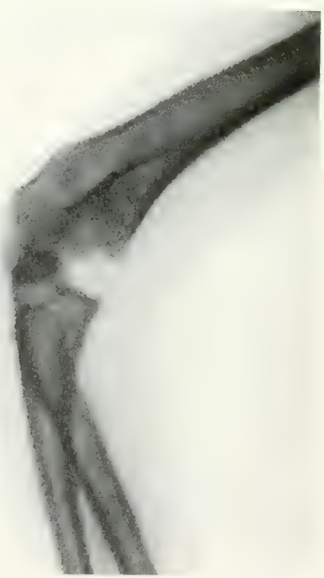


Fig. 416.

* Not published, so far as I know.

Fig. 417.—Skiagraph of case of Figs. 415, 416, anterior view after operation.

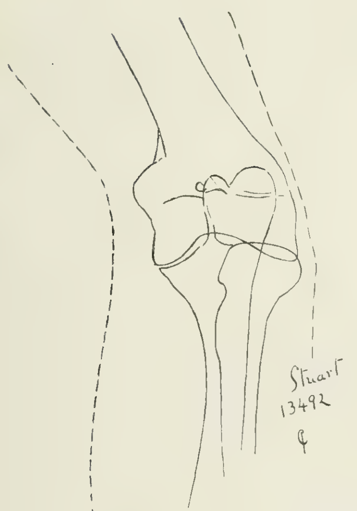


Fig. 418.—Gun-stock deformity in the adult, x-ray tracing (Stewart, B. C. H., 13492).

Fig. 419.—Gun-stock deformity of the left elbow. Tracing of arms. Child of four years. Supracondylar fracture.

Fig. 420.—Skiagraph of case XXXVII, lateral view.

Fig. 421.—Skiagraph of case XXXVII, anterior view.

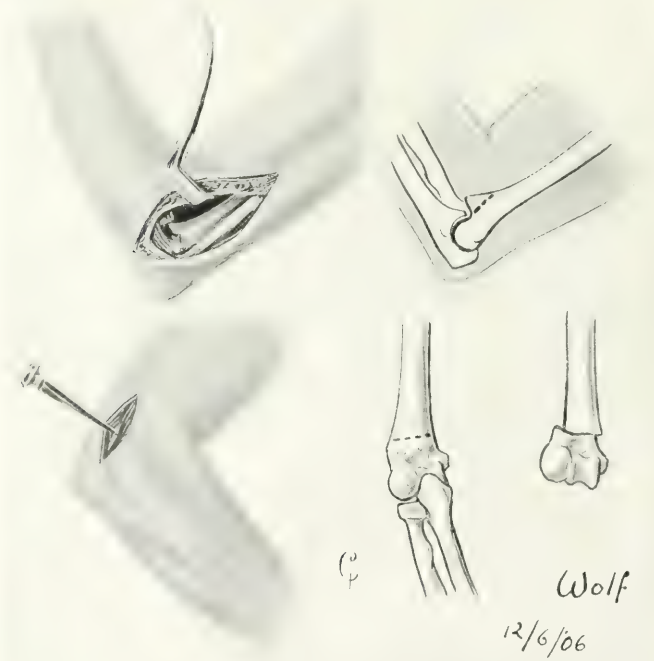


Fig. 422.—Details of operation on case shown in Figs. 400, 405, 406. Incision was made to the outer side, the prominent spur resected, and then a transverse osteotomy was done to correct the gun-stock deformity.

Here and there *external condyle* fracture, like other intra-articular fractures, fails to unite.* Fortunately, this complication is rare. It is to be guarded against only by efficient and long fixation. If union does fail, there is nothing for it but nailing or excision of the fragment, which operations, however, promise at least a useful joint.†

Since the above was written I have operated on one such case with perfect union without sacrificing the condyle. The broken surface was refreshed, the condyle pegged in place with a drill, which was removed later; union was perfect, and motion excellent. This is evidently the method of choice.

Fig. 423.—Result of operation shown in Fig. 422 in removing the check to flexion.

Fig. 424.—Result of the operation, seen from the front. Improvement, but not absolute correction of the lateral deviation.

Internal epicondyle fractures amount to little in end-results, as a rule. For a time there is almost always a conspicuous atrophy of the forearm muscles that have their origin from this process (Fig. 385); this is only temporary. Rarely there is a slight permanent loss of extension.

The Gun-stock Deformity

The gun-stock deformity is "cubitus varus." It is the loss or reversal of the "carrying angle." The carrying angle is the normal angle formed between the axis of the forearm and the axis of the humerus when the arm is supinated. It normally disappears in prona-

* Cases of such non-union are not excessively rare apparently. I reported two such cases in the Annals of Surgery, 1902, and have seen three more since. Cooper gives a cut of a specimen (see Fig. 308), and Poland (Traumatic Separation of Epiphyses, p. 428, Fig. 116) gives an additional case.

† I have done such excision only in one case of compound fracture of the external condyle. The result was a moderate gun-stock deformity, but perfect motion and entire restoration of strength.

tion, and does not exist, even in supination, when the arm is flexed. It is the result of a normal obliquity in the transverse axis of the joint at the lower end of the *humerus*, not of the forearm. Its loss or reversal results from a fracture which obliterates or reverses the obliquity of this joint.

Such a fracture in practice is always a fracture *above* the condyles, or an epiphyseal separation; in short, a lesion traversing the whole width of the humerus. It does not result from fracture of either condyle alone.

It has been maintained that the deformity depends on irregular growth from traumatic damage to the epiphysis. Riedel has reported one case in which this undoubtedly happened, but it must be very rare.

The reversed deformity, "cubitus valgus," and *increase* of the carrying angle, is far less usual, and, as a result of fracture, the writer has only seen it, save in cases of trifling deviation, in cases of non-union of the external condyle.

Apart from trauma, cubitus valgus occurs with cases of congenitally short radius, and, like cubitus varus, it is a not infrequent sequel to rickets.

In some persons, apparently normal and with no trace of old rickets, the arm is straight and there is *no* carrying angle. The angle varies very greatly in different individuals. In any given individual it is nearly always the same on both sides. It is stated that the angle is greater in women than in men. If this is true, it is a rule with many exceptions.

Operation for Gun-stock Deformity.—Ordinarily, this deformity is of no consequence as to function. Consequently, few patients call for operation.

Operation is indicated in some cases for extreme deformity or for secondary arthritis (from mechanical cause) interfering with function.

Operation is very successful. The operation usually indicated is an osteotomy above the epiphyseal line, done from the outer side with a chisel. The technical difficulty is avoidance of nerves. The arm is put up in extension in plaster. The results are next to perfect where operation is done for this deformity alone.

Other Operations on the Humerus at the Elbow After Fractures

Interference with the ulnar nerve by the internal epicondyle calls for immediate operation (excision of the fragment), and in certain cases of luxation with epitrochlear fracture in which the fragment has slipped into the joint we have no resource but operation.

So, too, if the fracture of the capitellum has left a fragment loose in the joint, it should be removed.

If, after union, we have a *spur* interfering with flexion (see Fig. 389),

this may be chiseled away; the results may be classed as fair to good. *Perfect* function is rarely attained, but the operation may be called satisfactory, on the whole.

Operations aiming at the reëstablishment of a filled-up coronoid or olecranon fossa have not been very successful in my hands, despite repeated trial.

Operations for *simultaneous* correction of gun-stock deformity and removal of spurs seem hardly to be recommended. I have done three such, with improvement in all, but I think there would have been greater betterment if I had done either operation alone. The combined operation presents great difficulty in proper postoperative fixation.

Certain cases of old backward or back and outward luxations (reduced or partly reduced) appear from time to time, in which there is

Fig. 425.—Volkmann's ischemic paralysis following fracture of the humerus. With the fingers flexed the wrist can be extended.

Fig. 426.—When the fingers are extended, the wrist is flexed. This is characteristic, and is a result of the shortening of the long flexor tendons always occurring in this process.

great overgrowth of the external condyle, either following fracture of the condyle or resulting from periosteal overgrowth. All my operative cases of this sort (3) have shown improvement, but only one, in a child, got improvement enough to make so severe an operation as is called for seem particularly worth while.

Volkmann's Contracture.—Volkmann's contracture is a paralysis, not from nerve injury, but from muscle ischemia, often due to tight bandaging, apparently. A paralysis ensues, involving *all* muscles in the region of the constriction. Later the paralysis lessens, but there is already a fibrous infiltration and a shortening of the muscles. Tests show that it is muscles not joint adhesions that limit motion (see Figs. 425, 426), and with a little care we may differentiate this from nerve lesions and from the common stiffening of muscles after fixation.

The differentiation is important, for the prognosis of ischemic

paralysis is very bad; the power of the muscles is poor, and any gain in motion from stretching or cutting is apt to be lost by fresh scar contraction.

The matter is not entirely hopeless, however. In the case shown in Figs. 425, 426, forcible stretching, followed by massage and active and passive motion, brought about great improvement, which was permanent.

Orthopedic treatment is of little avail.

Lengthening of tendons has given results in some cases,* shortening the bones in others.†

FRACTURES OF THE FOREARM JUST BELOW THE ELBOW

Fractures in this region are somewhat rare. Such fractures are produced by direct violence or by violence transmitted from the hand alone, or as an associated lesion in various dislocations of the elbow. Direct violence is rarely received at the proper point. Ordinary falls on the elbow may break the ulna, but even if they strike the ulna, they are apt to damage the humerus, rather than the ulna itself.

The head of the radius is pretty well buried in muscle masses, which protect it from direct blows.

Falls on the hand damage the wrist oftener than the radial head.

Fractures of the radial head complicating elbow luxation are not very rare; usually only a piece is driven off the radial head.

In practice we meet with the following lesions:

(1) Fractures of both bones at the level of the neck of the radius.

(2) Fractures of the ulna alone, either just above or just below the coronoid process, with or without associated dislocation of the radius.

(3) Fractures of the coronoid process alone.

(4) Fractures of the olecranon.

(5) Isolated fractures of the radial head or neck.

Fractures of Both Bones (High)

These are most commonly the result of a direct blow or of crushing, as by machinery. They are naturally very apt to be compound. The displacement varies, but it is apt to be of the forearm forward and upward. They are, of course, loose fractures, and so far as the writer's experience goes, are not likely to be comminuted, nor is there apt to be any serious damage to nerves or vessels. If they are compound, diagnosis is easily made. Such fractures almost necessarily involve the joint, and call for a thorough cleansing and disinfection, during the course of which the diagnosis is easily made by direct inspection.

* Froehlich, for instance, reports 8 cases treated orthopedically or by tendon lengthening. Reference: Jour. Amer. Med. Assoc., July 17, 1909.

† Rolland (Lancet, October, 1905) gives detailed report of such a case.

If the fracture is not compound, it becomes simply a question of identifying landmarks and of making sure that the injury to the radius is a fracture, and not a dislocation. It may be somewhat difficult to be sure that there has been an injury of the radius of any sort. The existence of crepitus on rotation proves nothing, because rotation will give crepitus transmitted from the ulna. Mobility with the ulnar fracture is very considerable, even with the radius intact. With the radius also gone we have a flail-joint of an exaggerated sort. Diagnosis of the fracture of the ulna needs no discussion, because this bone is subcutaneous at this level, and may be palpated.

Treatment.—If the fracture is compound, the ulnar fracture is to be wired or otherwise fixed. It may or may not be well to wire or suture the radius or to remove its head. If it is comminuted or so impacted as to impair motion, it is better out. The one thing which should *not* be done is to remove the radial head without making sure that enough of the neck has been left to insure against its slipping out of the orbicular ligament. The argument given against wiring or suturing fragments of the radius is that it is likely to interfere with rotation. This is not likely to happen, but, as a matter of fact, the radial head is so hard to get at that the *conservative* operation of suturing is hardly practicable without doing more harm than good.

Fig. 427.—Compound fracture of olecranon. Split of radial head and neck. Crushing injury. Olecranon wired. Radius reduced and held in forced supination. Perfect recovery. The patient returned to his work as a bench machinist.

These fractures often do better than would be expected, so it may be well not to do too much.

With regard to the treatment of *simple* fractures, it comes down to a question of the best possible reposition and the application of an internal angular splint and a posterior forearm splint. The tendency to deformity seems to be toward a downward bowing of the ulna (see right-hand cut, Fig. 436), due to gravity.* The pull of the biceps is supposed to be important; it is not vigorously operative after a few days.

In case of poor result, late operation, particularly for excision of a deformed radial head, may come in question, but this does not concern us in the fresh treatment of simple fracture at this point.

* In cases of fracture a bit lower down (of the upper third of the forearm), this tendency is even more marked, and not very uncommonly a serious deformity develops, even under the physician's eye

Fracture of the Ulna Alone

Fracture of the ulna may occur just above the coronoid process—that is, through the joint, or just below it. In either case, but especially

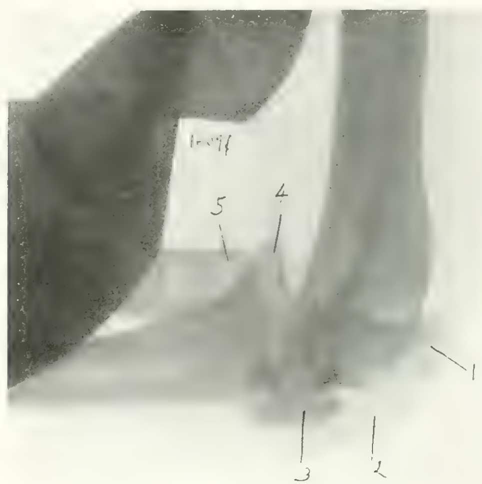


Fig. 428.—Dislocation of both bones forward, with a break in the ulna just into the joint: 1, 2, Olecranon; 3, external condyle; 4, coronoid process; 5, radial head.

in the latter, there may be an associated dislocation of the radius forward or outward, or there may be no damage to the radius at all. If the

Fig. 429.—Double fracture of the ulna. Dislocation of the radius forward. The head of the radius was excised, the olecranon fracture sutured, the lower fracture wired.

fracture is above the coronoid (*i. e.*, an olecranon fracture), there is some tendency of the upper fragment to be pulled backward by the

triceps (Fig. 435). At whichever point the break occurs there is a tendency to original displacement of the lower fragment forward in

Fig. 430.—Backward dislocation of radius (with splintering of head); fracture of ulna with displacement backward.

Fig. 431.—Condition when I first saw the case. There was no union in the fracture of the ulnar shaft; the radial head (partly reformed) was utterly loose; the arm was useless and painful.

case the radius is displaced, probably due to the direction of the smashing force.

Diagnosis.—There is no serious difficulty in diagnosing these fractures. There are both mobility and crepitus, and their site may readily be determined by manipulation. If the break is *through* the joint, we have a

Fig. 432.—After operation. The radial neck was confined in a new orbicular ligament, made of fascia and of fibers of the supinator brevis and the fracture refreshed and wired.

Fig. 433.—Side view of same case. The result of operation was a fixation of the radius with rotation preserved, but union of the ulnar fracture was not secured. Function improved, but not very good.

simple *olecranon* fragment; if it lies lower, there is abnormal mobility of the forearm *as a whole*, even if the radius is intact and not luxated.

Treatment.—If the ulna can be brought into good position on an ordinary internal angular splint, no more fixation than this is required. If, however, the fracture is hard to hold, this is one of the cases that distinctly justifies open operation for wiring, stapling, or suturing of the fracture.

If the fracture is complicated with radial dislocation, it would probably be a mistake to treat it other than by open operation on the ulna. *With the ulna fixed*, the radial dislocation calls only for the ordinary replacement and proper pads to maintain replacement at a right angle or in flexion. Without operation there is risk of malposition of the ulna and of unmanageable recurrence of the radial dislocation.

Fig. 434.—Sketched from findings in a case of compound elbow fracture of the writer's. Luxation of both bones forward, with smashing of the ulna below the joint, and with the breaking out of a piece of the radial head at *a*. This piece was removed and the ulna sutured with heavy silk. Recovery of motion practically perfect.

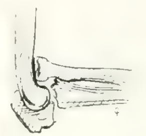


Fig. 435.—Check to flexion in luxation of radius forward with ulnar fracture (diagram).

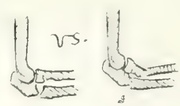


Fig. 436.—We may have merely ulnar fracture with the not very serious rocking backward of the upper fragment, or there may be a break in both bones, necessarily limiting extension and destroying practically all pronation and supination of the forearm. The distinction between the two is not always easy.

With all the fractures below the elbow so far considered, the ill results to be guarded against are *non-union of the ulna* and *interference with flexion and rotation*. Interference with rotation may come from excessive callus of the radius, but is much more likely to come from deviation of the axis of the ulna or from imperfect reduction of the radius, as seen in the accompanying sketch (Fig. 436). Interference with flexion must follow if the forward displacement of the radius persists (Figs. 429, 431, 435).

Fracture of the Coronoid Process

Fractures of the coronoid are accorded a place of apparent importance in all text-books, and the picture given of the symptoms and the directions for treatment would not lead one to suspect that this is one of the rarest lesions—almost one of the fictions of surgery.*

* Ferguson said that, in a dislocation of the forearm backward, "the coronoid process will probably be b oken."

Malgaigne thought the fracture more prevalent than the reported examples would lead us to suppose, basing his opinion largely on experimental luxations on the cadaver.

Liston wrote: "The coronoid process is occasionally pulled or pushed off

There is no manner of doubt that fracture of the coronoid has occurred in a few cases, but in nearly all of these cases it was a mere complication of crushing fractures or of other extensive injuries. It does not occur often enough to be worth consideration, even with these cases or with dislocations.

I have seen the diagnosis made in a good many instances, and have repeatedly tried to verify it by skiagraph or otherwise, and, save in Crandon's case (Fig. 437), in every instance have found that the diagnosis had no basis in fact. If this fracture is present, there *should be* pain on the front of the arm on active flexion, there should be local tenderness, and possibly a small palpable fragment. The fragment would *not* be drawn up by the brachialis internus, as is stated, simply because this muscle is inserted well below the tip of the process, and a fracture could hardly do more than split the area on which it is inserted. There would, no doubt, be some increased mobility of the ulna forward and back when the arm is bent, but unless the lateral ligament on the inner side—and the anterior ligament as well—were torn, this mobility would have to be slight. If the ligaments were so torn, such free mobility would not *prove* a coronoid fracture, as every one who has seen recurrence of an elbow luxation can testify. The writer is frank in saying that he probably could not recognize a coronoid fracture except by aid of the skiagraph.

Fig. 437.—Fracture of the coronoid process, with reduced subluxation of the elbow backward (courtesy of Dr. L. R. G. Crandon).

Treatment.—The classic description involves treatment in acute flexion. This scheme was apparently devised with regard to the brachialis muscle; there is, however, no question but that this would be the position best calculated to secure proper position and to avoid any interference with flexion by displacement of the fragments.

Results.—In the specimens known, union was by fibrous tissue only. So far as our data go, the presence of this process of bone, united by fibrous tissue, would have little or no effect upon the joint or its use.

from the shaft, more especially in young subjects. I saw a case of it lately in which the injury arose in consequence of the patient, a boy of eight years, having hung for a long time from the top of a wall by one hand, afraid to drop down."

Hamilton cites these remarkable statements, and shows how all our supposed lore on coronoid fracture and its muscular causation originated from them. In fact, there are a few specimens without history, some of them doubtful, and no one knows anything about the fracture clinically. It must be very rare.

Wainwright, Clin. Soc. Transactions, xix, p. 332, reports an apparently sound modern case of fracture of the coronoid and of the radial head, in which the coronoid was resected after three months.

Dr. L. R. G. Crandon in 1905 (verbal communication), in a case of fresh compound elbow luxation tending to recur, removed a broken coronoid and also a loose chip off the head of the radius. To him I am also indebted for the x-ray in Fig. 437.

Fractures of the Olecranon

These are not unusual. They may occur either from direct violence or from muscular action of the triceps. The former is the more common mode of origin. The importance of differentiating, as far as may be, between these causes, lies in the matter of probable separation of fragments, as in the case of fracture of the patella. At the elbow, however, fractures unquestionably the result of a *direct blow* may show *considerable separation.*

Whether from the one cause or the other these fractures are very apt to occur across the narrowest part of the bone. If fracture is the result of a direct fall, this is the part of the ulna most readily split by the convex trochlear surface, and it is the part most readily broken by triceps action, as this trochlear surface acts as a fulcrum.

Extensive splintering, even from direct violence, is the exception; the great majority of fractures show a clean cross-break.

Fig. 438.—Sketch of normal ulna from above. This shows the narrow weak point in the olecranon opposite the trochlear surface of the humerus.

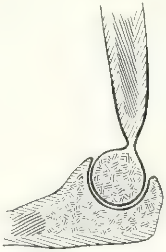


Fig. 439.—Sagittal section of the bones of the elbow-joint. The olecranon is broken where it is of least thickness, opposite the bottom of the curve of the trochlear surface, as a rule.

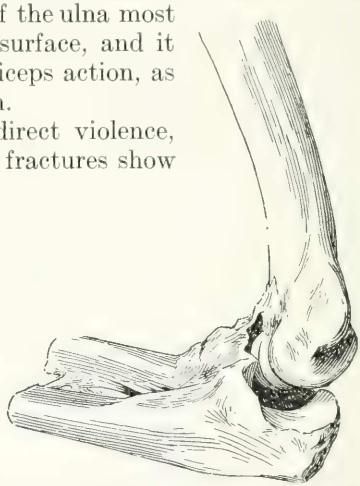


Fig. 440.—Relations of olecranon to elbow-joint; all olecranon fractures are necessarily intra-articular.

This may, especially in children, be a clean break across, substantially without displacement, and practically *subperiosteal* (Fig. 445). Such fractures resulting, especially in children, from falls on the elbow, have been described as a special fracture to which Quénu's name has been appended.

When there has been somewhat more tearing, although the periosteum is gone, there are lateral expansions running down from the triceps tendon to the sides of the joint at the back, which are not likely to be torn across entirely. They limit separation of the fragments, and if unevenly torn, may cause a tilting to one or the other side, as the fragment separates.

Even with little separation there is some rotation up and backward of the fragment (Fig. 446). Where there is no obstacle, separation becomes very considerable, even in the fresh cases, as a result of effusion. Extreme separation comes later, apparently as a result of gradual giving way of the fibrous bands above noted under muscle pull.

Symptoms.—There is a prompt loss of power to extend the arm, which may be complete or may be only partial. Extension of the arm in the ordinary position is possible simply by gravity; there may even be enough left of the lateral expansion of the triceps tendon to give some actual *power* of extension. Roughly speaking, however, power to extend the arm is lost.

The arm may be held in any position. There is nothing characteristic about it. Half-flexion is usual.

There is a prompt swelling, of rather characteristic outline, best understood by reference to Fig. 441, differing decidedly from the other

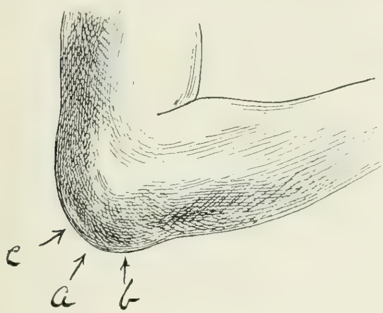


Fig. 441.—Appearance of olecranon fracture: (*b*) End of ulnar shaft; (*c*) displaced olecranon; (*a*) bulging distention of joint between fragments (schematic).

Fig. 442.—Upper left, olecranon fracture; upper right, normal elbow; lower sketch, olecranon bursitis (schematic).

fractures, and only likely to be counterfeited by a hematoma or by bursal effusion.

On grasping the end of the olecranon and fixing the forearm in extension there is no difficulty, in fresh cases, in obtaining mobility, or in bringing the fragment close enough to give crepitus (Fig. 447). The amount of separation is usually slight at first.

Treatment.—The time-honored treatment of olecranon fractures is by the straight splint, with straps holding down the fragment. Latterly, the operative treatment has been more in vogue and much advocated.

No treatment ought to be made the absolute routine; the old-fashioned splint, the somewhat neglected right-angle splint, and the operation all have their distinct indications.

If there is no tendency *at all* to separation of the fragments,—a not uncommon condition,—then there is nothing to be gained by operation.

and there is no necessity of using the cumbersome straight splint (Fig. 448). The writer has repeatedly secured good results, as have others, with the ordinary right-angled "internal angular" splint, with straps and pads to secure approximation and to prevent *rotation* of the fragment.

If there is moderate separation, let us say, under a finger's breadth, then the case becomes debatable. With elderly patients, or with those in infirm health, splint treatment is, of course, indicated. Young athletic persons, or men who have to do manual labor, had better have wiring or suturing done, because under severe strain even a short fibrous union is likely to stretch.

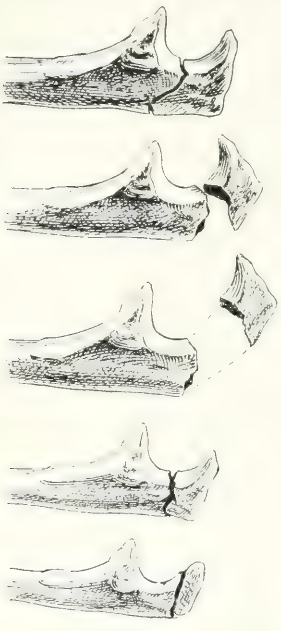


Fig. 443.—Olecranon fracture. Upper three sketches show the varying displacement; the fourth shows the form of subperiosteal fracture that sometimes results from a direct fall on the elbow; the olecranon is split by the impact of the humerus. The fifth sketch shows separation of the epiphysis.

In the majority of patients, who do not definitely belong to either of these classes, it is a question *for the patient to decide* whether he is willing to run a small risk for the sake of a *short convalescence* and a *practically perfect arm*, or whether he would rather wait longer without operation for an imperfect, but probably serviceable, result.

Waiting with the notion of a possible *later operation* is not wise. Late operations are serviceable, but do not give perfect results, because the shortening of the triceps muscle is a bar to full flexion when the fragments are brought together and held.

If there is already, at the time the case is first seen, a very considerable separation of the fragments, operation should be advised unless in the face of some definite contraindication, such as a bad heart or diabetes, for instance, that would contraindicate *any* operation, for the results of palliative treatment in such cases are not good.

Compound fractures will be operated on in all cases.

In all instances where operation is *not* advised, or where it is refused, the straight or nearly straight splint is to be used if there is any tendency to separation. The most serviceable form is a long, straight, narrow piece of splint board, reaching from just below the wrist to the axilla, and a little wider than the arm (Fig. 448). This is padded so as to allow for about 15 degrees of flexion at the elbow. This is done because a position of full extension of the arm soon becomes intolerable. The arm is strapped to this splint with the hand in supination and with

both upper arm and forearm firmly fixed. An adhesive strap is carried just above the upper end of the loose fragment, and is so placed as to

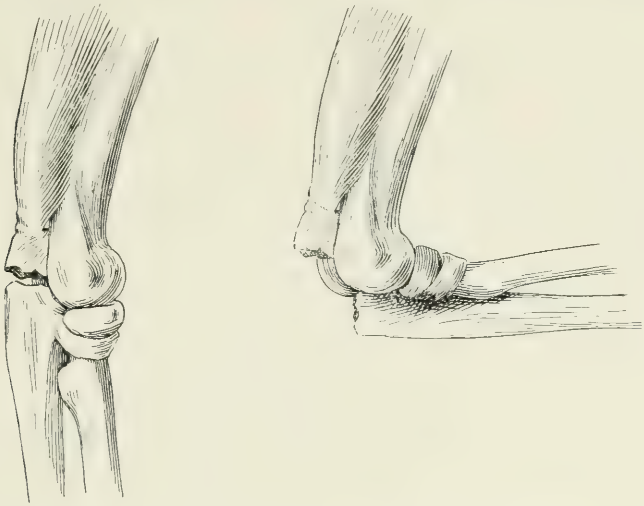


Fig. 444.—Separation of fragment of olecranon by the triceps in flexion of the elbow (schematic).

hold it in the best position it can be brought to; the strap is made fast to the splint low down. The arm is then bandaged, and is to be carried at the side. This is at best a very uncomfortable apparatus and very

Fig. 445.—Fracture of olecranon without separation of fragments (radial head also damaged).

unwieldy. The straps are to be changed every few days to make sure that we are getting the best possible position. At any time after three

weeks, if there seems to be a beginning serviceable union, this apparatus is exchanged for a splint with a movable angle (Fig. 337), and the arm is brought to a position of greater flexion by slight changes in the angle two or three times a week. The strapping down of the fragment is still continued. This process is carried on until the arm comes near a right angle, not beyond. At about five weeks after the injury this should have been accomplished. At about six or seven weeks the arm may be put in a sling without splints. *Active* motion will not be attempted earlier than two months. Massage and moderate passive motion may be begun earlier.

Operative Treatment.—If operation is decided on, it becomes a question of date. Operations done *immediately* after the injury usually do well. If the operation cannot be done within twelve hours, it had better be postponed for about ten days. The interval between has been shown to be a poor period to operate on *any* joint fracture. The clot has begun to organize, but seems for the time being to have lost bactericidal power. At the end of ten days there is a good deal of organization of the clot, and the tissue resistance seems to have returned.

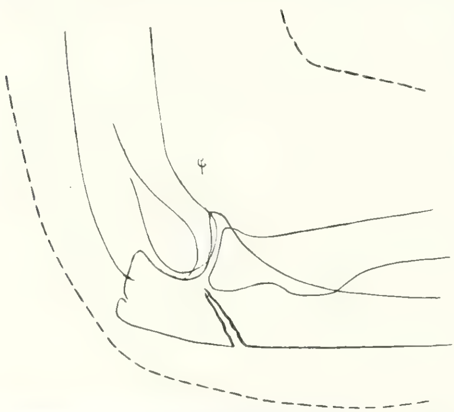


Fig. 446.—Olecranon fracture with rotation of fragment, but almost without separation.

Fig. 447.—Palpation to determine separation of olecranon. The ulna just below the joint is fixed by the thumb and fingers of the left hand.

As to the mode of operation, the incision is of no especial consequence, except that a longitudinal incision, just to one side of the subcutaneous surface of the bone, will give the *least troublesome scar*. The broken bone-ends are exposed, and are cleaned with a sponge and the curet; all

clots are removed; the joint is thoroughly washed out with salt solution, or with salt solution containing 1 to 10,000 or 15,000 parts of corrosive sublimate, followed by simple salt solution. The fragments are drilled as in the sketch (Fig. 449). Either wire or kangaroo tendon may be used for suture; the latter is perfectly serviceable, and usually preferable. The fragments are brought together, making sure that no fibrous tissues intervene, and the sutures are tied. Suturing of the triceps expansion is done, if practicable. The triceps layer is not always a very definite one, and the procedure does not seem to be really necessary. The wound is closed without drainage, and the limb is put on a splint or in plaster in partial extension, or, if there is no tension, on a right-angled splint. The time of *absolute* fixation should be about a month; after this, only protection and passive and active motion are called for. Unlike fractures treated conservatively, these cases give an arm which is fit to use for *fairly* vigorous work in *three* months, instead of *six*.

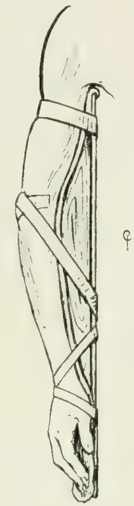


Fig. 448.—Olecranon splint. A straight board, padded to allow for an obtuse angle at the elbow—180 degrees is an unbearable position. The splint is strapped on, and then straps, running obliquely, are drawn so as to drag down the loose upper fragment of the olecranon.

Results.—Cases operated on and wired give, with few exceptions, union without separation, and usually union by bone. The result is an arm practically, if not absolutely, as good as new.

The cases conservatively treated give, in case there is little or no separation, a result nearly as good, although the union is usually, if not always, fibrous. In case the separation can be kept down to a half-inch or less, there may be a little loss of full active extension, but the power of extension is substantially normal. The writer knew one man with such an elbow who was a very fair performer at "shot-putting," the severest possible test of pure extensor power.

Fig. 449.—Lines of drill-holes for wire or other suture. They must be so directed that the suture shall lie entirely outside the joint.

If there is more separation than this, there begins to be loss of strength, because the projecting lever formed by the olecranon is partly lost, and the mechanism of the joint becomes a "strap-lever" only, like that producing extension of the fingers, for example, an essentially weak joint mechanism.

With *considerable* separation the results may be, and often are, very poor.

It must be remembered, however, that an arm may be very useful for ordinary purposes which has very little power of *active* extension. At the worst, olecranon fractures are likely to produce only loss of this power.

Any considerable loss of range of motion is rather unusual. Ankylosis hardly results except from failure of asepsis in open operation, which is, fortunately, rare. I have seen fibrous ankylosis in one case treated with a splint: later open operation and suture gave an excellent elbow.

Separation of the Epiphysis of the Olecranon

There is an epiphysis at the end of the olecranon, originally comprising most of it, gradually lessening until, at about thirteen or fourteen

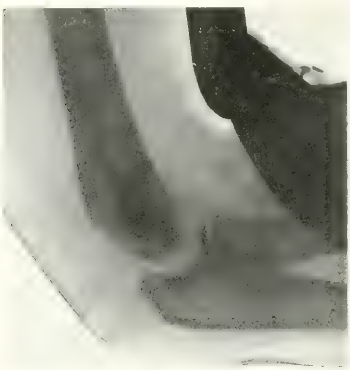


Fig. 450.—Olecranon epiphysis. No ossification center.

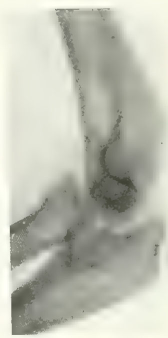


Fig. 451.—Lateral view of epiphysis at twelve years. Definite, though small ossification center.

Fig. 452.—Olecranon epiphysis; small ossification center. Age, nine years (Warren Museum, specimen not numbered).

Fig. 453.—Olecranon epiphysis. Age, ten years (Warren Museum, specimen not numbered).

Fig. 454.—Olecranon epiphysis at twelve years (after Poland).

Fig. 455.—Olecranon epiphysis at eighteen years (Warren Museum, specimen 417).

years of age, it is barely more than a scale at the tip end, not always represented by any osseous center shown by the *x*-ray, even at this age.* Occasionally, it becomes separated. In the three cases of this sort I have seen † all were between thirteen and seventeen years of age, all were

* There may be *two* ossification centers. (See Figs. 456 and 457.)

† Cotton: Boston Med. and Surg. Jour., June 28, 1900, and one case observed since that time.

the result of *indirect* violence, and all presented the same clinical picture, namely, primary swelling and disability, followed by lameness and partial loss of motion. This loss of motion appeared on attempting active flexion or on active hyperextension. Two of the three cases

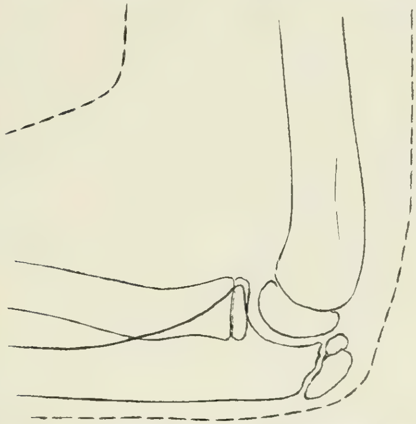


Fig. 456.—Double ossification center in olecranon epiphysis.

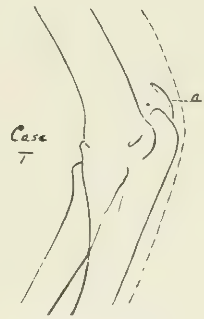


Fig. 457.—Separation of olecranon epiphysis in boy of sixteen: *a*, Posterior line of olecranon epiphysis.

seen had gone for some time without treatment. In all, the clinical picture was obscure until a small mass was found, just above and at the tip of the olecranon, and movable upon it. The triceps tendon inser-

Fig. 458. Double ossification center in olecranon epiphysis (outlines retouched)

Fig. 459.—Persistent olecranon epiphysis in adult (also shows fracture, impacted, of radial neck).

tion is evidently not seriously involved. The distance of separation of the fragments is very slight. All recovered perfect function and motion after a few weeks' fixation, at first in partial extension; later, with some flexion. In all the union was apparently fibrous only, and some little

lateral mobility of the fragment remained. Cases of this sort do not resemble ordinary olecranon fractures. The symptoms are far less

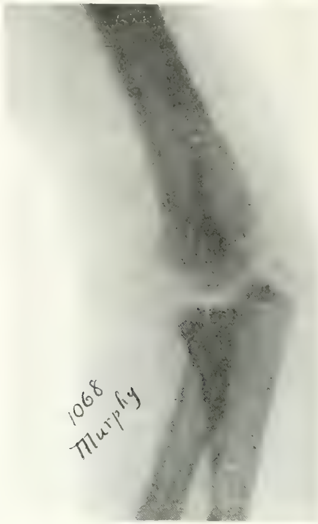


Fig. 460.—Separation of olecranon epiphysis. Clinically, the epiphysis was freely movable from side to side, not upward.

severe, comparable to those produced, for instance, by the tearing loose of the epiphysis at the tubercle of the tibia.

Fractures of the Radius Near the Elbow

(1) These fractures may occur *at the neck, below* or *within* the annular ligament.

(2) They may, more often, occur just behind the head, that is, between the annular ligament and the head.

Commonly, there is also splintering of the head.

Often there is impaction.

(3) There may be simply a splitting off of a part of the head.

Fractures of the first group, not uncommon in combination with ulnar fracture, are rare as independent fractures. Those of the second group are common, relatively speaking, and may occur in children as well as in adults. The third sort may rarely be found as a complication of backward luxation, a part of the radial head being driven off by the external condyle as it passes beneath it. Direct violence may give fractures corresponding to any of these groups.

Symptoms.—The classic symptoms given apply rather to the fractures at or below the neck or, at all events, do not cover the more common forms of damage to the head and neck alone. Crepitus on rotation

is present usually only in fractures below the orbicular ligament, or in case one or more chips have been loosened from the head. There is, ordinarily, no displacement that can be felt, wherever the fracture is, unless the break be below the ligament.

Most conclusive of the symptoms is the failure of the head of the radius to rotate with rotation of the wrist or limitation of the arc of such motion. This failure may not necessarily be accompanied by crepitus. There is apt to be well-marked *local* tenderness. There is no characteristic attitude, and unless there are other injuries, motion in flexion and extension is unimpeded, though sometimes painful. Motion in pronation and supination is, however, definitely interfered with, and supination is apt to be more limited than pronation. This is true of both impacted and unimpacted forms. In either case there is usually bony locking, either because loose fragments are in the way, or because the shape and angle of the radial head are changed. There is also limitation of motion as a result of pain, also from involuntary spasm of muscles, even when the pain is not very great.

Fig. 461.—Fracture of radial neck, high up. Shows impaction (same case as Fig. 459, which shows the side view; there is also in this plate a separation of the internal epicondyle) (outlines reinforced).

It makes no difference where the exact site of the fracture is: spasm

Fig. 462.—Fracture of radial neck, high up, with impaction.

on rotation is characteristic of *all* fractures of the radial head and neck, and not present in cases of fracture of the lower end of the humerus.

This gives a valuable point in differentiation; on this point alone the writer has several times diagnosed damage to the radial head which was confirmed by the x-ray, and on the *absence* of such spasm in the presence of some interference with flexion and extension has felt free to correct diagnoses of fracture of the radius previously made, and has done this so far without mistake.

In cases where only the head of the radius is broken, or where the

Fig. 463.—Fracture of radial head. Fragments all consolidated (after Hamilton's Fig. 76) (Mütter Museum, A 105).

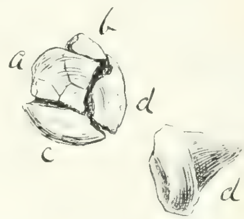


Fig. 464.—Fragments of splintered radial head. Chips b, c, and d were loose. They were removed, as was also the portion a, that was not broken loose.

head as a whole is driven down and impacted on the shaft, we have as diagnostic signs only the spasm thus noted, some local tenderness, and occasionally a click (not true crepitus) in the joint on rotation, apparently caused by the irregularity of motion of the deformed head. These cases are apt to show little reaction and little disability in the early stages.

In case there has been a *splitting* of the radial head, we may have a

Fig. 465.—Same case as Fig. 464. Range of voluntary flexion and supination after operation.

Fig. 466.—Range of voluntary pronation (same case).

widening which mechanically interferes with motion of the joint and so adds to the symptoms, or we may have an entire slipping loose of a fragment or fragments. With a fragment loose in the joint we have the picture of a foreign body in the elbow-joint, and the symptoms referable to it depend simply on its location. It is pretty sure to interfere with

rotation, and according to its position it may get in the way of either flexion or extension.

Lesions of the radial head and neck occur in children as well as adults, though not common at any age.

Treatment.—Treatment must necessarily vary according to the position of the break above or below the orbicular ligament. With the break below this ligament our only concern is to restore the fragments to position, and our

Fig. 467.—Range of voluntary extension shortly after operation. Eventually the arm became as useful as ever (same case).

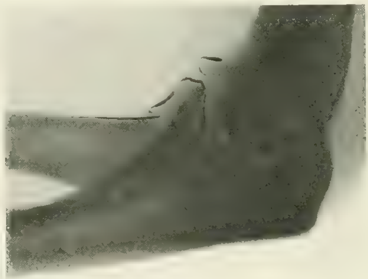


Fig. 468.—Splintered radial head (case of Dr. F. B. Lund).

greatest obstacle is likely to be the pull of the biceps. It is not practicable in most of these cases to use any splint other than a right-angled one, but it seems that acute flexion with a pressure-pad over the outer side of the radius would be the ideal treatment. If we

Fig. 469.—Fracture and displacement of radial head, with backward luxation of the elbow (sketched from Poland's plate). (This plate shows the double ossification center of the olecranon epiphysis not uncommonly seen.)

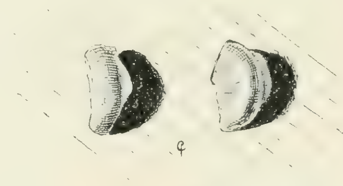


Fig. 470.—Portion of radial head removed by Dr. Lund from case shown in Fig. 468.

use a right-angled splint, special padding is to be used over the upper end of the lower fragment in front and to the outer side.

In case of fracture across the neck of the radius within or just above the ligament we have an entirely different condition to deal with. Unless the orbicular ligament is torn, or unless the neck has slipped out

of it, we can have no displacement of anything except of the head *within* the elbow-joint.

Unless the fracture was originally impacted, it is very improbable that any bony union will result.*

Probably the most serviceable form of treatment, so far as results are concerned, is an excision of the loose head. The only danger in doing this is that manipulation during operation might pull the neck out of the annular ligament. This danger is largely theoretic. The mechanism of the joint precludes any conservative operation attempting reduction and fixation of fragments.

Fig. 471.—Splintered radial head; fracture of external condyle also.

In cases where the head of the radius is *impacted in place* no manipulation is called for. We must put the joint at rest, on a right-angled splint, for three or four weeks, beginning moderate active motion at two to three weeks. In these cases the result is often good, and the only things to *guard against* are breaking up of impaction, and stiffness from too long fixation. Results may not be good, and excision may be called for later, but *not primary excision* in this type.

Fig. 472.—Impacted fracture of radial head and neck (outlines have been reinforced).

Fig. 473.—Impacted fracture of radial head and neck. The explanatory sketch in the right-hand corner shows the relation of the fracture to the epiphysis.

On the other hand, in case of fractures involving such smashing of

* Malgaigne gives an excellent plate of a fracture of this sort in which twenty-seven years of active use had given no union, and, curiously enough, had produced very little absorption of the opposing surfaces.

the head as to interfere with free rotation, results are poor, and, as a rule, there is nothing to do but to resect the head or to resect such parts of it as are in the way of rotation. This is commonly to be done without waiting more than ten days.

When part of the radial head has been split off and the fragment is loose, no treatment is worth considering except resection of this fragment, unless there is some definite contraindication to any operation. Left alone, the results, like those in fracture of the capitellum, can hardly be good, and those the writer has seen have been distinctly bad, with much interference in motion and with some joint irritation.

Operative treatment of injuries of the radial head may be the more readily undertaken because resection of the radial head in the adult causes no loss of function whatever. There is, after such resection, some reformation of a new radial head by cartilaginous growth (case Largess, see Fig. 430), but this probably does not affect the motions of the elbow-joint one way or the other. Apparently, the interosseous membrane and the oblique ligament are sufficient to support the radius against any longitudinal strain, provided the upper end of the radius is held close by the annular ligament. In children, judging from the conditions seen in congenital shortening of the radius (see Figs. 482 to 485), excision of this portion, which necessarily includes an epiphyseal line, would probably leave some deformity of growth, but in adults this does not become a question.

Fig. 474.—Diagram to show how a *part* of the radial head may be smashed off by the humerus in backward luxation of the elbow.

Separation of the Upper Radial Epiphysis

This is a rare accident, occurring only in small children: even in them it is less common, apparently, than fracture in this region.

Possibly there may be later interference with growth—probably very rarely.

In all other respects such separation is comparable to the fracture at like height.

CHAPTER XVI

THE WRIST

Injuries of the wrist are very common indeed; they occur usually as a result of trying to "break a fall," to save one's self in falling. In the young and vigorous, "sprains" of ligaments, ensuing synovitis, strains of muscle or tendon, etc., occur not rarely. In older persons nearly all wrist injuries entail fracture. It used to be taught by Dr. G. W. Gay that "there is no such thing as a sprain of the wrist," a statement calculated, by its intentional dogmatism, to rivet the student's attention on the overwhelming proportion of *fractures* in wrist injuries. In fact, "sprained" wrists prove even rarer than was thought when Dr. Gay so taught, for the *x*-ray now shows many bone "cracks" without displacement, previously unsuspected.

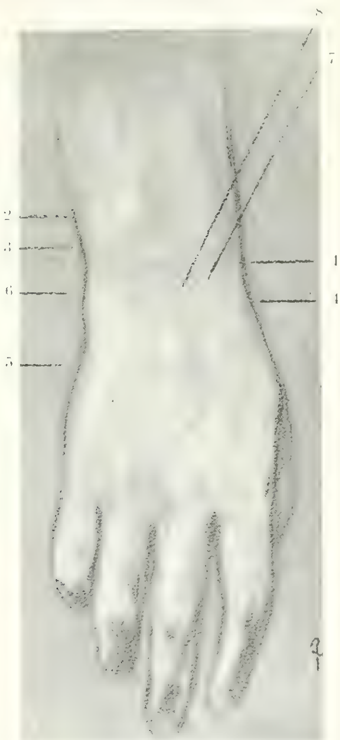


Fig. 475. Landmarks of the wrist: 1, Level of radial styloid; 2, level of head of ulna; 3, level of the styloid process of the ulna; 4, hollow between radius and metacarpal of thumb; 5, base of fifth metacarpal; 6, cuneiform; 7, scaphoid; 8, hollow over the neck of the os magnum.

Most wrist injuries are fractures, some are luxations and luxation fractures; a few are simple sprains. Injuries may be divided into—

(*a*) Radiocarpal luxations.

(*b*) Radiocarpal luxation with fracture of the radius (including Barton's and "reversed Barton's").

Fracture Near the Wrist:

(*c*) Colles' fracture.

(*d*) Reversed Colles' ("Smith's fracture").

(*e*) Epiphyseal separation.

(*f*) Fracture of both bones—low.

(*g*) Green-stick fracture of both bones.

(*h*) Fracture of the radial styloid.

(*i*) Luxation of the ulna (alone).

(*j*) Fracture of the ulnar styloid (alone).

Carpal Luxations:

(*k*) Of one row on the other (with or without associated fracture).

(*l*) Luxations of single bones.

(*m*) Subluxations of the carpal bones.

Carpal Fractures:

(*n*) Scaphoid fracture.

(*o*) Scaphoid fracture, with semilunar luxation.

(*p*) Fractures of other carpal bones.

Anciently, all wrist injuries were classified as dislocations of the

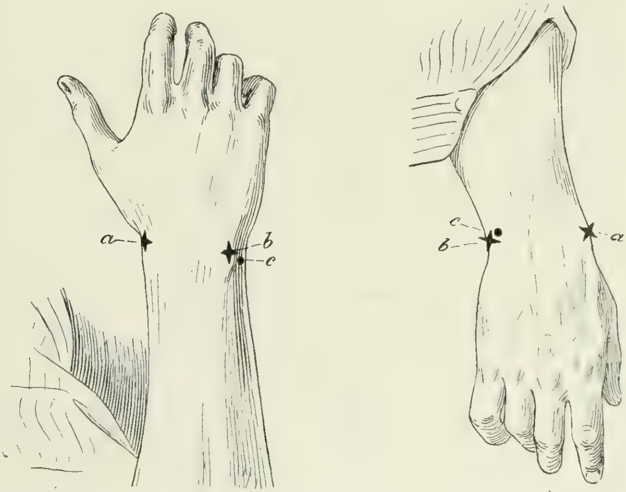


Fig. 476.—1. Supination. 2. Pronation. *a*, Tip of radius; *b*, styloid process of ulna; *c*, ulnar head. To illustrate that, in comparing the level of the styloid of radius with lower end of ulna, in supination, 1, the *styloid* of the ulna is felt, and that in pronation, 2, the *head* of the ulna is felt.

wrist. Pouteau,* and later Colles and Dupuytren, recognized the real nature of the common injury, but old ideas are hard to dislodge, and time wore on until near the middle of the last century before it was generally recognized that real dislocations of the wrist are really rare—so rare, in fact, that only a few surgeons have seen any such cases at all. Hamilton cited only 11 authors as having reported cases, and out of his very large personal experience he could add but two more—and one of these was a case of compound luxation from direct violence.

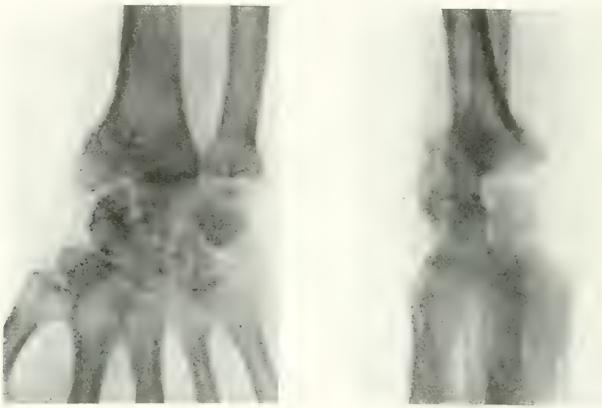
The majority of such rare dislocations of this joint as are reported

* Pouteau, Chirurgien en chef de l'Hôtel Dieu, Lyon; Oeuvres Posthumes de M. Pouteau, Paris, 1783, in vol. ii, p. 251, describing fracture of lower end of radius, at least thirty years before Colles' famous description in 1814.

are dislocations of the carpus *backward*. The writer has seen but two cases, both from direct violence.

RADIOCARPAL LUXATION. SIMPLE LUXATIONS BACKWARD AT THE WRIST

Etiology.—There would seem to be evidence that falls either upon the front or the back of the hand may produce this lesion. Falls on the palm must act by driving the carpus backward. Such falls, however,



Figs. 477, 478. Posterior dislocation of wrist with fracture of radial styloid and back edge of radius. The fracture has been allowed to unite, but without complete reduction of the luxation. There were no fractures of carpal bones. The carpus was excised later, with entire removal of deformity and restoration of motion (author's case).

usually give Colles' fracture; less often they result in fracture of the carpal scaphoid or in a "Barton's" fracture; least often of all is the pure dislocation met with.

That falls on the *back* of the hand should cause this luxation is

1 2 3 4 5

Fig. 479.—Differential diagnosis in *outline:* 1, Colles' fracture; 2, backward luxation of wrist; 3, mediocarpal luxation backward; 4, scaphoid fracture; 5, "Barton's" fracture.

hard to understand, but Hamilton's case, at least, seems conclusive.* The mechanism must be one of *overflexion* and of leverage across the

* Hamilton, Fractures and Dislocations, third edition, 1866, p. 611.

front edge of the radius, lifting the carpus from its socket. Such a fall will more usually give a "reversed Colles" ("Smith's") fracture of the radius.

Lesions in posterior luxation (on authority of Hamilton):

Constant:
- (*a*) Rupture of posterior and lateral ligaments.
- (*b*) Rupture of the anterior ligaments—more or less extensive.
- (*c*) Stripping up of extensor tendons from the back of the radius and ulna.

Inconstant:
- (*d*) Tearing of the skin—giving compound luxation.
- (*e*) Injury to tendons.
- (*f*) Injury to nerves in front of the wrist.

Diagnosis.—There should be no serious difficulty in recognizing the luxation, but the question as to whether or not it is complicated by fracture may be more troublesome.

The styloid processes of radius and ulna are always palpable in

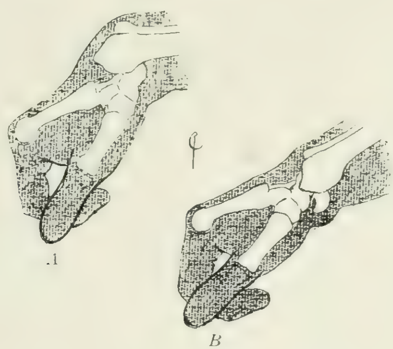


Fig. 480.—*A*, Dislocation of the whole carpus forward; *B*, dislocation of the semilunar bone forward (diagram of *outlines* of deformity).

wrist injuries, even if, owing to swelling, long-continued pressure is required to reach them. Once these points are located it is simply a question of the *site* of the prominence on the back of the wrist, as the accompanying diagrams show. (See Figs. 479 and 481.) Between the forms of displacement here met with there may be great difference in opinion and an actual difficulty in diagnosis, only to be solved by individual expertness of touch or by the *x*-ray. All of them—radiocarpal luxation, dislocation between the carpal rows, scaphoid fracture, and Barton's fracture—depend for diagnosis, like Colles' fracture, upon the recognition and the correct placing of the level of the backward displacement at the wrist.

But, hard as it may be to straighten out this series, the Colles' fractures and fractures of the radial styloid should be perfectly differentiated, simply by the mutual relation of the styloids of radius and ulna.

In both this relation is changed; in no other lesions is it disturbed. Permanency of reduction, and the absence of crepitus when reduction is accomplished, as indicating pure luxation, is, of course, of definite assistance.

Luxation of the wrist, whether forward or back, must of necessity give a greater actual displacement than any of these injuries except Colles' fracture, and gives a more definite and abrupt projection, formed by the front or back edge of the concave radial joint surface. (See Fig. 478.)

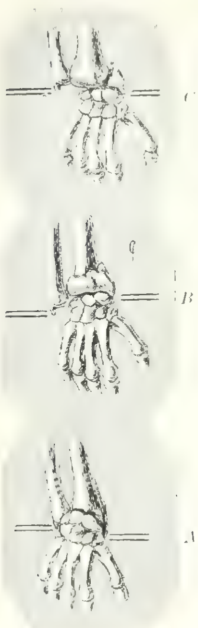


Fig. 481.—Relations of radial and ulnar landmarks in—*A*, Backward luxation; *B*, Colles' fracture; *C*, fracture of the radial styloid with displacement of the hand.

The position of the hand and arm is not constant or characteristic enough in luxation to differentiate this lesion from the carpal injuries, but the limitation of motion should help, at least as against Colles' fracture; the luxation gives, as always, a much more definite limitation of motion than the fracture, dependent on mechanical limitation as well as on pain and spasm.

Results are good with reduction. No cases of bad results following reduction are noted in the literature, and no disability from failure to reduce, or from entire lack of treatment, seems to be on record, if we except the case noted by Hamilton.* This was really a case of *partial luxation.* A year after reduction of a *total* backward dislocation of the carpus there was a constant recurrence of *partial* luxation on strain, with some disability.

Reduction.—Direct traction, with or without a rocking motion, has usually sufficed. Failing in this, flexion with forward traction should here be in place, as well as direct-line traction. Hamilton also suggests extension and *direct* reducing force by pressure. No fresh cases seem to be on record where reduction has offered any serious difficulty.

Treatment after reduction must consist of the usual period of about three weeks of rest for repairs, accompanied by any bandage or sling that secures rest and approximate fixation.

Luxation of the wrist backward complicated with *joint fracture* is Barton's fracture (*q. v.*).

FORWARD LUXATION AT THE WRIST

Forward luxation appears to be an extremely rare injury. An apparently sound case is related by Bransby Cooper.†

* Hamilton, third edition, p. 611.

† Treatise on Dislocations and Fractures of the Joints, Sir Astley Cooper, edited by Bransby Cooper: American edition of 1844, published by the Massachusetts

Differential diagnosis of such a lesion will concern itself with dislocation of *single* carpal bones forward, with reversed Colles', and with reversed Barton's fractures. (See diagrams, Figs. 479, 480.)

From isolated luxations of the carpus, wrist luxations forward should

Fig. 482.—Congenital luxation of ulna (with short radius).

Fig. 483.—The same case seen from the back.

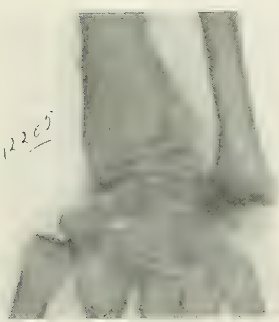


Fig. 484.—*x*-Ray of the same case as Figs. 482, 483.

Fig. 485.—Same case, lateral view.

be differentiated by direct palpation, and from reversed Colles' by determining the displacement of the radial styloid; the "reversed Barton's"

Medical Society, p. 420, Case cccxcvii. This case is curious in that the patient is said to have fallen on the *palms* of both hands and got a luxation of the wrist forward on the right, backward on the left.

Fig. 486.—Congenital forward luxation of the wrists from congenital spastic condition. Note also the inward subluxation of the feet. (Courtesy of Dr. J. S. Stone.)

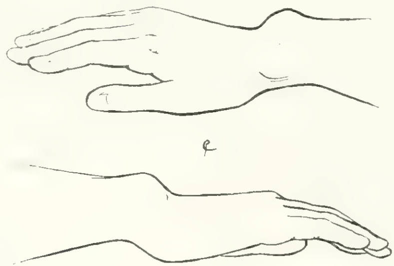
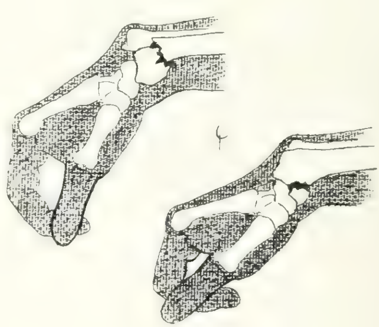


Fig. 487.—Madelung's deformity (sketched from Madelung's original plates).

Fig. 488.—No transverse fracture, but separation of the fragments from the posterior edge of the joint surface. Result of direct violence. Scaphoid also fractured (Warren Museum, 3776).

A



B

Fig. 489.—Outlines of deformity in—*A*, Colles' with anterior displacement; *B*, reversed Barton's fracture.

should present some differences (crepitus, etc.) even without the x-ray. There are no *real* data at hand to give more than a theoretic differential diagnosis between these forms.

Forward luxation with joint fracture is "Barton's reversed," q. v.

Lateral luxations, uncomplicated, seem not to occur: are, at all events, nowhere described.

Congenital luxation forward is best described by R. W. Smith.*

Madelung's deformity gives a similar picture† (Fig. 487).

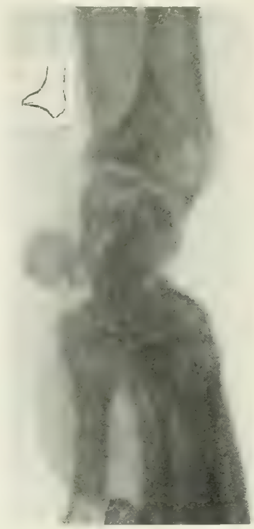


Fig. 490.—Skiagraph: Madelung's deformity (author's case). Note the changed shape of the radius and the abnormal obliquity of the joint surface shown in the corner sketch.

FRACTURE LUXATIONS

Fracture Luxations Displaced Outward

Lateral fracture luxations occur with fractured radial styloid (*q. v.*) or with "abduction Colles."

Barton's Fracture

This is a fracture of the posterior superior surface of the radius, with backward displacement. Barton, in 1838,‡ described such a fracture, but his cases seem, in fact, to be probable cases of Colles' fracture, wrongly interpreted. The fracture he described does, however, occur. (See Fig. 488.)

Etiology.—So far as known this is a variant of Colles' fracture, with like etiology, or is the result of direct crushing force.

Diagnosis.—This lesion differs from Colles' by the fact that, with a like displacement of the wrist, it does *not* give displacement of the radial

* Smith's article is in his "Fractures in the Vicinity of Joints," Philadelphia, 1850, p. 238.

These cases are not uncommon. They represent in some cases a defect in bone formation and growth, in some, the result of spastic action of muscles. (See Figs. 482–485, and compare Fig. 486.)

† Spontane Lux. der Hand. Madelung: Arch. d. klin. Chir., 1879, xxiii, 395.

Madelung's deformity is the result of oversevere work at or just before the period of puberty, at a time when the bones are in a "plastic" state. Such overwork results in a gradual flexion of the lower end of the radius; the ulna projects up and back. The condition resulting is shown in Fig. 490. No remedy has been suggested. Osteotomy would, of course, remedy the deformity; the question is purely whether it is worth while.

The relation of the lesion to late rickets has been considered by Gasne (Rev. d'Orthopedie, 1906, vii, 1522, 241).

Of late there has been a tendency to confuse what Madelung described with certain forms usually called congenital, and others probably rachitic; *e. g.*, compare De Witt Stetten: Surgery, Gyn., and Obstetrics, January, 1909, p. 4.

‡ Rhea Barton, Medical Examiner, Phila., 1838, p. 365. Barton's cases were probably, so far as one may judge, Colles' fractures only, but the lesion he described does, in fact, occur.

styloid in relation to the ulnar styloid. The break is of the back edge, and does not involve the styloid.

Treatment.—Reduction and treatment are those of Colles' fracture. Theoretically, there may well be greater difficult in maintaining reduction than with Colles' fracture.

"Reversed Barton's"

This, a chipping off of the *front* articular edge, is also a variety (rarely, if ever, diagnosed save by the *x*-ray), and treated accordingly.

Fig. 491.—"Reversed Barton's" fracture. There is anterior wrist luxation, with a chip torn loose from the anterior edge of the articular surface of the radius (see explanatory sketch to the left).

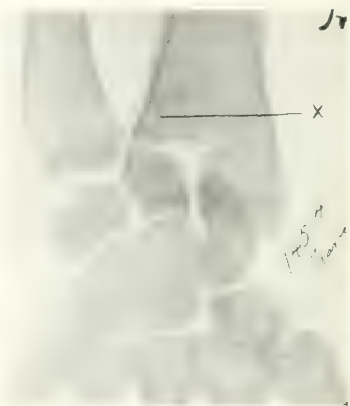


Fig. 492.—Same case. X points to position of the radial fragment, not clearly seen. In this case there was also a crack across the radius.

(See Figs. 491, 492.) Clinically, it is to be considered merely a variant of "reversed Colles'" fracture.*

COLLES' FRACTURE

This fracture was described by Colles, whose name it bears, in 1814.†

* Letenneur: Bull. Soc. Anatom., 1839, xiv, p. 162, described a case with antemortem and postmortem findings, as follows: Clinically: "Une luxation du poignet droit, en avant, compliquée d'une fracture de l'apophyse styloïde du radius."

After death, he found: "Une fracture de l'apophyse styloïde du radius, du côté droit, et du rebord anterieur de l'extremité articulaire de cet os."

Whether we should limit the term "reversed Barton's fracture" to cases in which the radial styloid is *not* involved is, after all, an academic question, of no grave importance if we keep the lesions squarely in mind.

† By the English-speaking peoples it is called Colles' fracture; by others, more often known as Dupuytren's.

Knott, in the Med. Press and Circular, 1881, gives an excellent review of the literature on Colles' fracture, well worth reading from a historic point of view.

Pouteau, 1783, first described the lesion. M. Pouteau, Chirurgien en chef de

in a masterly essay, conspicuous for brevity as well as for clearness, which appeared in the Edinburgh Medical Journal. He pointed out not only what had been known before, that a fracture of the lower end of the radius *might* occur, but also that it is a *common* fracture—and *the* common fracture of the radius. Twenty years previous to this description Pouteau had clearly described the fracture, but his description and arguments availed nothing against the authority of the eminent French surgeons of that time.

Fig. 493.—Old fracture united with but little displacement; much excess of bone formation at seat of fracture.

Fig. 494.—Fresh case of fracture; fracture transverse, with some displacement upward; partial fracture of ulnar styloid at its base.

Colles' work met reasonably prompt recognition, but it was a long time before the old diagnosis of "dislocation of the wrist" fell into disuse.

Colles' original description was of a fracture occurring 1½ inches

l'Hôtel Dieu, Lyon. Oeuvres Posthumes de M. Pouteau, Paris, 1783; in vol. ii, p. 251, describes the fracture of the lower end of the radius.

Colles in 1814 brought it into real prominence in England, but it was left for *Dupuytren, 1820,* to establish among the French the frequency of fracture of the carpal end of the radius, and to prove practically the rarity of luxation of wrist of which he never saw an example. *R. W. Smith,* at nearly the same time as Dupuytren, brought into prominence the same view. Amusing stories are related about the fierce clinical disputes at the Hôtel Dieu between *Dupuytren* and his colleagues, *Pelletan* and *Marjolin,* until finally the point was settled by the accommodation of a patient in providing an autopsy. Many men tried to offer a single explanation which would cover the mechanism for all cases. *Bouchut in 1834* called attention to the obliquity of the line of fracture from above and behind, downward and forward. *Velpeau in 1842* called attention to the characteristic S-shaped deformity, which he likened to a *dinner fork. Voillemier in 1842* wrote a most elaborate and exhaustive thesis on the subject. He believed the most frequent form of fracture to be what he described under the name "fracture from penetration," and to this class of cases he relegates all those in which the history would lead to suspicion of fracture, yet the predominant symptoms indicate merely a sprain, when deformity and crepitus are absent, and an obscure mobility is the only local sign justifying the idea of fracture. *Nélaton in 1844* adopts this impaction theory, slightly modified. *Jarjavay, in 1846* contested these views of impaction most strenuously. *Malgaigne* in his work on Fractures and Dislocations gives prominence to the theory of "arrachement," to which *Voillemier* and *Verneuil* had called attention.

above the carpal extremity of the radius. In point of fact the break lies somewhat lower than this, on the average, about $\frac{1}{2}$ to $\frac{3}{4}$ inch above the articular surface.

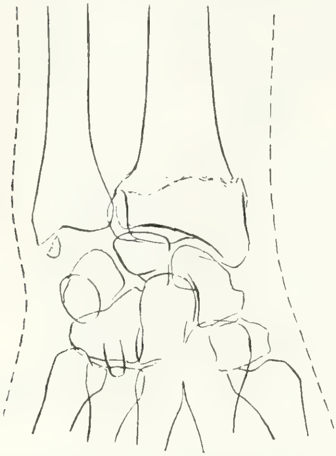


Fig. 495.—Transverse fracture of the radius, with little displacement; fracture of ulnar styloid, tracing from x-ray.

The name of Colles' fracture is rather loosely used to cover *all* fractures of the lower quarter of the radius; this is unfortunate, because fractures occurring at a height of two inches or more, or fractures of both bones, do not show the peculiar features of the typical Colles' fracture.

Etiology.—A strife of many years was waged in the medical press as to the mechanism of this fracture—a strife between the advocates of the theory of "*arrachement*" (that is, of the theory of those who held that the fracture was produced by *hyperextension*, through the pull of the anterior ligament on the lower end of the radius), and of those who believed that the fracture was a result of a *breaking strain*, received somewhat obliquely upward and backward, transmitted from the hand through the carpus, without any particular stretching of ligaments, and without the ligaments or the muscles playing any particular part in the mechanism.

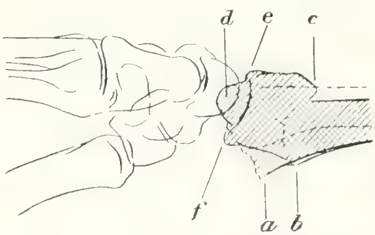


Fig. 496.—Transverse fracture of the radius, some backward displacement; much rotation backward. The ulna is shown in dotted line; a, b, lower end of radial shaft; c, back edge of lower fragment; d, styloid process of radius; e, f, articular surface of radius rotated backward (tracing from x-ray plate).

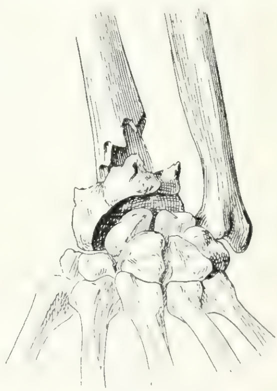


Fig. 497.—"Amputated three inches above condyles for compound Colles' fracture, with rupture of radial artery and subsequent spreading gangrene." A projecting spur anteriorly caused arterial injury; the fracture transverse, with loss of substance and with considerable backward displacement; lower fragment comminuted at back and ulnar side (specimen of Dr. J. C. Warren, Warren Museum, No. 8117).

Undoubted cases of *fracture by arrachement* have occurred, but it is now pretty well agreed that they are exceptional.

In the vast majority of cases the second theory holds good, and the reason why the bone gives way at this particular place is, as was long ago pointed out, because the cortical layer at this level becomes very thin. The shaft structure changes into the *cancellated bone of the expanded end.*

Roughly corresponding to the obliquity of the breaking force, the

Fig. 498.—Fracture without displacement, oblique upward and outward; epiphyses still ununited.

Fig. 499.—Transverse fracture with apparent impaction. Avulsion of ulnar styloid.

fracture is usually slightly oblique upward and backward. Falls in which the weight comes on the *ulnar side* of the hand, or otherwise in such fashion as to throw the hand into abduction as it strikes, tend to produce obliquity of the fracture line upward and outward, with a corresponding outward displacement.

Strangely enough, there are cases in which falls on the *back* of the

Fig. 500.—Transverse fracture with apparent impaction; avulsion of ulnar styloid.

Fig. 501.—Transverse fracture practically without displacement.

closed hand have produced, not reversed Colles', but nearly typical Colles' fracture, oblique upward and backward.

More usually, however, falls on the back of the hand seem to produce a transverse fracture, or a fracture oblique upward and forward.

Fractures by "*arrachement*" tend, in fact, to produce more nearly

Fig. 502.—Transverse fracture: marked *rotation backward* of hand and of lower fragment.

Fig. 503.—Same case as Fig. 501 (side view). In the print this looks like a "Barton's" fracture; in fact, it was not.

Fig. 504.—Transverse fracture; *displacement in toto and rotation backward.*

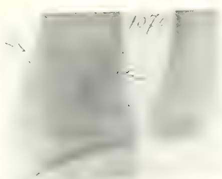


Fig. 505.—Transverse fracture with almost no displacement.

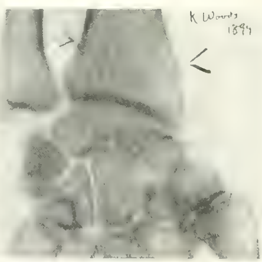


Fig. 506.—Transverse fracture (without displacement) at points marked.

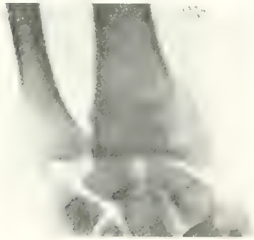


Fig. 507.—Transverse fracture, practically without displacement.

Fig. 508.—Irregularly transverse fracture with little displacement.

transverse fractures, very close to the joint; fractures experimentally so produced on the cadaver are apt to be oblique upward and *forward*.*

Lesions.—There has been some tendency to speak of our knowledge

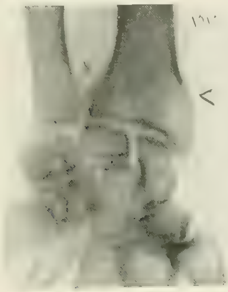


Fig. 509.—Transverse fracture at points shown. No displacement, but the ulnar styloid is gone.

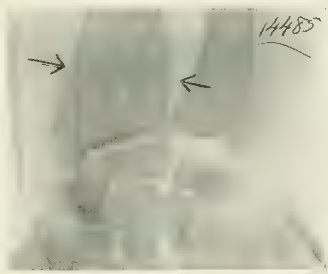


Fig. 510.—Transverse fracture; slight displacement.

Fig. 511.—Transverse crack (slightly oblique up and out) without displacement. This is an "automobile wrist," resulting from a "back-fire" in cranking.

of lesions in detail as if such knowledge was based entirely or mainly upon the x-ray plates. As a matter of fact, there have been fresh

* Experimental Colles' Fracture, F. J. Cotton, Jour. Boston Soc. Med. Sci., May, 1898, vol. ii, No. 10, p. 171.

specimens enough from autopsies or from amputations in compound fractures, etc., to say nothing of old postmortem specimens, to give us definite data as to *all* the lesions that do, in fact, occur—more definite data, as to many of them, than can be obtained from even the best x-ray.

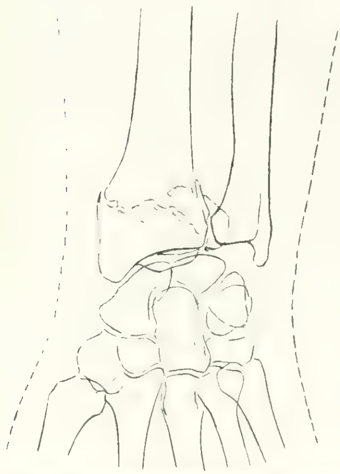


Fig. 512.—Transverse comminuted Colles' fracture (x-ray tracing).

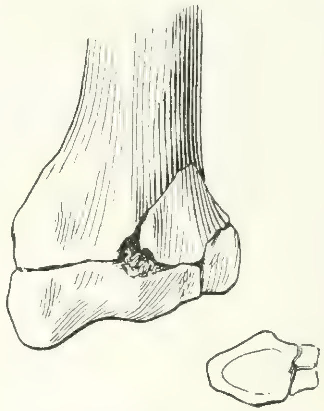


Fig. 513.—Comminution of lower fragment at inner edge, result of direct violence. Lower sketch shows same specimen from below (joint surface) (Warren Museum, specimen 1038).

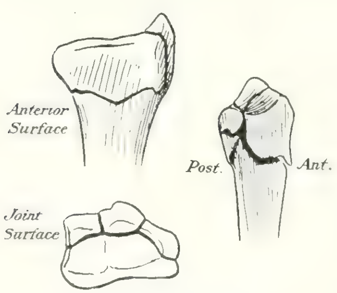


Fig. 514.—Fracture showing lines of comminution into joint; plane of fracture nearly transverse; backward displacement; some crushing and loss of substance at the back (after McGraw and Walker).

Skiagraphs of the ordinary Colles' fracture are, moreover, apt to be very deceptive indeed, unless examined with expert care, and even then unless we have pictures taken in two planes.

What we have really learned by the x-ray is the *comparative frequency* of comminution and of other of the severer lesions, which had previously been supposed to be limited, as a rule, to the cases of extreme trauma. We have, then, learned nothing new of the *possibilities* of this fracture, but something of the *frequency* with which given lesions occur. In a somewhat extended article* on these pathologic lesions,

* Cotton: The Pathology of Fracture of the Lower Extremity of the Radius, Ann. Surg., August, 1900.

Codman, in 1900, collected and analyzed the x-rays of 140 cases of wrist fracture (Boston Med. and Surg. Jour., 1900, cxliii, pp. 305 and 318).

Morton (Lancet, March 16, 1907) analyzed 170 cases studied radiographically. The results of these studies do not differ essentially from those of the writer.

based upon specimens as well as *x*-rays, the writer employed the following classification, which is perhaps as serviceable as any.

I. *Simple Transverse Fracture.*—A fracture across the full width of the bone, most often within an inch, or an inch and a quarter, above the joint surface. Not infrequently the fracture lies not over $\frac{3}{4}$ of an inch

Fig. 515.—Transverse fracture, comminuted, with little displacement (taken after reduction).

Fig. 516.—Same case, seen laterally, after reduction. Shows displacement slightly *forward*.

from the joint surface. There may be impaction with this form or there may not. The transverse character of the fracture is, moreover, no argument against the presence of extreme backward displacement or extreme backward rotation. The transverse line seems to argue little as to the direction from which the fall is received, but the cases in

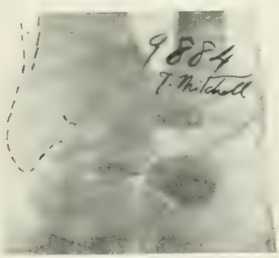


Fig. 517.—Fracture, nearly transverse, showing comminution (outlines reinforced).

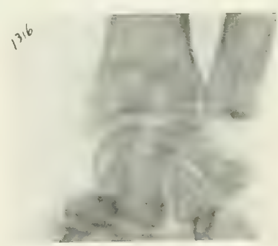


Fig. 518.—Comminuted Colles' fracture. Note that radial joint is level with ulnar.

which there was fracture by "arrachement" (including the cases of "automobile fracture") seem to belong in this transverse class, practically without exception.

II. *Comminuted Transverse Fracture.*—This fracture differs only in its comminution from the form just described. There is not necessarily

any separation of the different pieces. This sort of comminution seems to be frequent, and often not detected; not uncommonly it may be made out in the x-ray, but it is probably present in many cases where it does not appear even in the skiagraph. Certainly in a very large proportion of the transverse fractures studied as *specimens* comminution is recorded. According to the figures of Bennett, Power, Hutchinson, and the writer, such comminution seems to be present in well over half of the museum specimens. Not all of these represent unusually severe trauma. The failure of the fragments to separate to any great extent explains the reason why these splits are not consistently demonstrated by the x-ray. Fortunately, the presence of such comminution seems to be of comparatively slight importance unless the fragments are separated. The line of comminution shows no exact constancy, but it is rather apt to start from the ulnar facet, running along closer to the back than the front,

Fig. 519.—Epiphyseal separation; left radius showing external and anterior surfaces (Warren Museum, No. 6212).

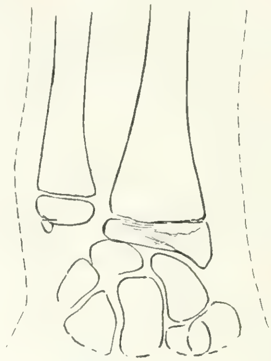


Fig. 520.—Separation of the epiphysis of the radius, not now displaced; comminution of the epiphysis; fracture of the ulnar styloid at its base without displacement (tracing from x-ray).

Fig. 521.—Epiphyses at wrist; not obviously abnormal.

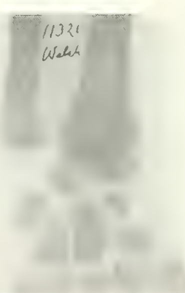


Fig. 522.—Epiphyses at wrist; about five years.

and breaking out posteriorly either into the groove for the common extensors or the groove for the radial extensors. Here and there is a case in which a line branches off from this line and runs forward toward about the middle of the front of the bone. Cases where the line of

Fig. 523.—*X*-ray of separated epiphysis on the left-hand plate (no present displacement).

splitting is directly anteroposterior are decidedly infrequent. In a few cases the splitting is in on entirely atypical and irregular lines.

III. *Separation of the Radial Epiphysis.*—The lesion is most common between twelve and eighteen years, but *pure* separation of the epiphyses is more apt to occur in younger children; in older ones the separation follows the epiphyseal line anteriorly, while poster-

Fig. 524.—Separation of epiphysis of radius (reduced).

Figs. 525, 526.—Separation of the radial epiphysis.

iorly the fracture runs upward, splitting away a bit of the shaft adherent to the epiphysis. There has been a rather large opportunity to study these lesions, postmortem and in compound fractures, for this condition seems often to be a product of very severe trauma; it is often

found in children dead from severe falls, and the proportion of compound injuries is far greater than with other wrist lesions.

Bruns (Arch. f. klin. Chir., 1881, xxvii, p. 240) has recorded a series of these lesions; and Poland's book,* as usual, includes all known cases in admirable detail.

The lesions resemble those of Colles' fracture, save for the *less extreme* displacement of the ulna and the different relations of the periosteum. The periosteum is torn anteriorly, but is *stripped up* posteriorly as a sheet. The displacement of the epiphysis is backward, with a backward rotation. Forward displacement does rarely occur, whereas marked displacement toward the radial side does not seem to be recorded in the epiphyseal separations.

Fig. 527

Fig. 528.

Fig. 527. Same case.
Fig. 528. Same case: from the side.

Here and there the radial epiphysis is *split*. Apparently antero-posterior splitting is somewhat more frequent here than in Colles' fracture proper. Rarely is there separation to any extent at the split.

Very commonly the whole epiphysis is barely more than started from its place—hardly displaced.

In these epiphyseal separations we have no problem of crushed, "pulped," bone to consider; all anatomic parts remain intact—divided, perhaps, but intact as to total mass.

There is a problem as to results, for at this point interference with growth from epiphyseal lesion is not very rare. Goyrand, Hutchinson, Holmes, Poncet, and Bruns all reported such cases in their time, and E. Wyllys Andrews (Ann. Surg., 1902, xxxv, p. 663) reports a more modern case.

The possibility of such result is an argument for accurate *operative* reduction. Such reduction the writer has twice carried out; it is easy and satisfactory.

IV. *Fracture Oblique Upward and Backward.*—This is what we have in the past supposed to be *the* typical form of Colles' fracture. If we regard very slight grades of obliquity, it probably is typical, but *sharp obliquity* occurs less often than the *approximately* transverse line.

The reason why a very considerable obliquity was always predicated of this fracture until lately is the same reason underlying the dogma of constant impaction, viz., because conclusions were drawn from examination of old specimens, long consolidated, in which the new bone

* *Loc. cit.*

formed in the triangle between shaft, lower fragment, and periosteum was reckoned as part of the lower fragment. (See Figs. 534, 529.)

There is no rule, of course, as to the angle of obliquity. Any slope beyond 25 or 30 degrees is, however, extremely exceptional.

These cases show comminution in just the same way and tending toward the same lines as in the transverse fractures.

Fig. 529. — Obliquity upward and backward is less usual than is supposed. Displacement backward with rotation backward is usual.

Often the periosteum is stripped up at the back, and when the space under it, and the triangle in front (also shown in black in this cut), become filled up with new bone, the appearance suggests both obliquity of fracture and impaction. It is for this reason that so many museum specimens have been misinterpreted.

V. *Oblique Upward and Forward.*—The number of good specimens or complete records of this form of fracture are too few on which to form a conclusion. Smith* first called attention to it, and Roberts† has written a wonderfully complete monograph on the fracture with forward displacement, collecting 24 cases and 31 specimens that may be so classed. Unfortunately, the records of many of these instances are incomplete.

It may be said that obliquity upward and forward does not necessarily imply displacement forward, nor does it even necessarily mean violence applied to the back of the hand, though such violence may often be the cause and such displacement may often occur in these cases. Displacement *backward* may, however, occur with the

Fig. 530.—Fracture, oblique up and back, with extensive splintering of the cortical layer on the back (see the tilted bone plates).

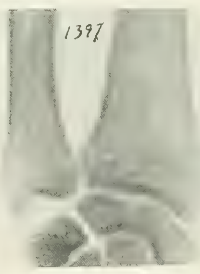


Fig. 531.—Same case. The bone plates broken out at the back of the wrist are shown here, though faintly (both Figs. 530 and 531 were taken after reduction).

Fig. 532.—Fracture, oblique up and backward, just above the epiphyseal line. Backward displacement with some rotation.

* R. W. Smith: A Treatise on Fractures in the Vicinity of Joints, etc., published in Dublin, Philadelphia, Lea and Blanchard, and in 1850, page 162 ff. May I venture to recommend the reading of this almost forgotten work? Nothing better, or so good, has been done in this branch of surgery since.

† J. B. Roberts: A Clinical, Pathological, and Experimental Study of Fracture

forward obliquity. Forward displacement from overzealous reduction is usually prevented by untorn periosteum, etc. It occurred, however, I am sure, in the case shown in Fig. 537.

VI. *Fracture Oblique Upward and Outward.*—These fractures are

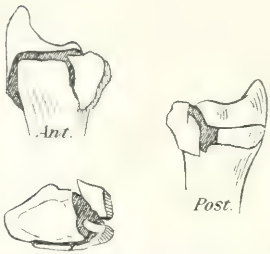


Fig. 533.—Fracture, oblique up and backward; irregular comminution (after Rutherford).

Fig. 534.—United fracture; displaced backward; depression at back filled up with new bone (Warren Museum, No. 5194).

rather common. It does not necessarily follow, from the marked outward displacement of the hand, that there is any corresponding obliquity in the fracture line. Where there is such obliquity we may have—

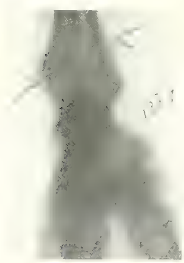


Fig. 535.—Colles' fracture, oblique up and forward (see arrows), though with very little displacement.

Fig. 536.—Fracture with displacement up and *forward*, seen from the ulnar side; the ulnar displacement is *backward* (after R. W. Smith's plate).

(A) Fracture upward and outward through the whole width of the bone (common).

(B) Fracture transverse toward the inner side, but tending up and outward externally (rather common).

(C) Oblique fracture penetrating the joint (rare).

of the Lower End of the Radius, with Displacement of the Carpal Fragment Toward the Flexor or Anterior Surface of the Wrist, 1897.

Bennett (Dublin Jour. Med. Sci., 1902, cxiii, 241–244) treats of this among other rare fractures. I suspect it is not so very rare, but how many cases owe the anterior displacement to original trauma, how many to reposition, is hard to say.

In connection with all these subclasses well-marked *rotation* upward and outward is more constant and characteristic than displacement out-

Fig. 537.—Photographs of case of the writer's with *backward* displacement of the ulnar head. The fracture of the radius was transverse, with slight forward displacement.

Fig. 538.—Fracture, oblique up and forward, just above the epiphyseal line. Displacement forward.

Fig 539.—Same case. Shows only the site of fracture, and that but faintly (see the *dots* at the ends of the line of fracture). (Case under writer's care at the Children's Hospital.)

ward *in toto*. It is the rotation, not the outward displacement, that gives the characteristic abduction of the hand often seen clinically. Great *displacement* outward is necessarily limited by the ulnar ligaments,

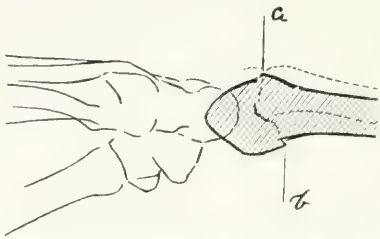


Fig. 540. Fracture of radius up and forward, with backward displacement of the ulna (shown in dotted lines): *a*, Lower end of upper fragment, overlapping; *b*, upper end of lower fragment, overlapping (tracing from *x*-ray).

Fig. 541.—Fresh fracture of radius, oblique up and outward; much outward, some upward, displacement; moderate rotation of lower fragment; fragment freely movable under ether.

Fig. 542.—Combination of transverse and oblique fracture lines; anteroposterior split into joint; fracture of shaft of ulna (views from front and from below) (after Westbrook's plate).

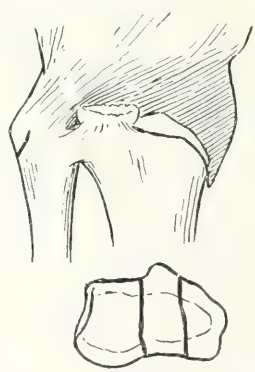


Fig. 543.—Comminuted fracture running obliquely down and inward into the joint; fracture of the semilunar bone; partial fracture of ulnar styloid (after Hunt's plate) (anterior view and view of lower end).

which are not often entirely, though often extensively, torn. There is no rotation (corresponding to the supination which makes *backward displacement* possible without much tearing of these ligaments) that

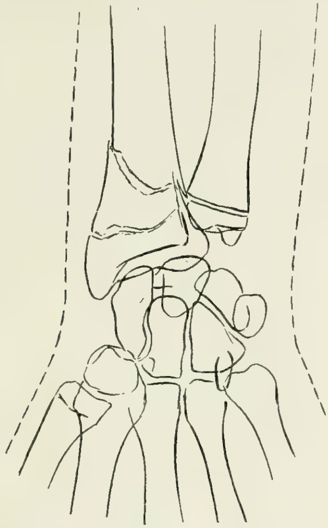


Fig. 544.—Fracture of the radius above the epiphyseal line, oblique upward and outward—after reduction; epiphyses of radius and ulna ununited (x-ray tracing, writer's case).

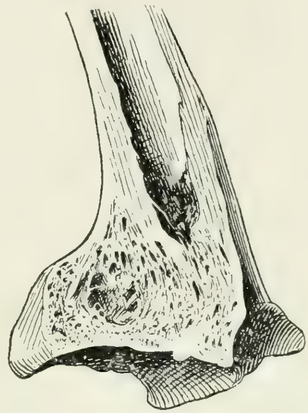


Fig. 545.—United fracture; displacement upward and outward; shows the "impaction line" (Warren Museum, No. 1040).

can permit outward displacement without extensive ligament rupture.

VII. *Fracture Luxation of the Radial Styloid.*—This is not a very uncommon accident; it

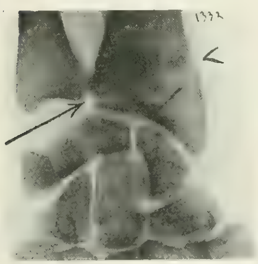


Fig. 546.—Fracture, oblique up and outward (see arrows) (x-ray *after* reduction).

Fig. 547.—Fracture, oblique up and outward, just above epiphyseal line. Extreme displacement.

Fig. 548. Same case as Fig. 547. Note that the displacement is purely *outward*, not backward; the ulnar head is *not* driven forward.

seems to occur as the result of a fall on the palm with sharp abduction

of the hand. Not infrequently it is associated with fracture of the carpal scaphoid. This fracture shows the same rupture of the liga-

Fig. 549. Displacement outward may be from oblique fracture clear above the joint or from fracture running into the joint.

Fig. 550. Outward displacement with a rocking that carries the radial styloid (and the hand) strongly out and up. May rarely occur with an approximately transverse fracture.

ments as occurs in Colles' fracture, and the same displacement of the ulna, though of less degree.

As a rule, there is no impaction.

The lesion very much resembles in appearance the "abduction Colles." As a rule, displacement of the hand is less. There is less abduction of the hand, and little if any shortening. The clinical diagnosis depends upon localized tenderness and upon the determination of a difference in level between the radial and ulnar styloids, with mobility of a fragment which *includes the radial styloid.* Unless this mobility can clearly be made out, diagnosis is uncertain without the x-ray. There is not apt to be much displacement forward or backward. There is usually displacement upward, *not* obviously connected with any pull upward by the supinator longus.

Fig. 551.—Fracture of radial styloid; separation of ulnar styloid at its base, from direct violence (Warren Museum, No. 4631).

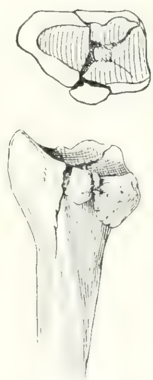


Fig. 552.—Cracks running vertically (the famous Bigelow specimen in the Warren Museum).

VIII. *Fractures Oblique Downward and Outward.*—These may show as a fracture running obliquely through the whole bone, not showing, except for this peculiarity, any difference from the ordinary transverse fracture, or they may show as a fracture downward and outward into the joint surface, splitting off a fragment attached to the ulna. This fracture shows nothing clinically characteristic except the absence of obvious displacement of the hand in any direction, with the presence of mobility, tenderness, and possibly crepitus. This is a very rare injury, resulting probably in nearly all cases from direct violence.

IX. *Cracks of the Radius Not Penetrating the Width of the Bone.*—These are the famous "stellate fractures," fractures in which splits in various directions run from the articular surface for a varying distance up or up and back. So far as we know, they are the result of direct violence by crushing. They are very rare: three specimens constitute

Fig. 553.—Skin outlines in fracture of the radial styloid *vs.* those of simple displacement outward in Colles' fracture (diagrammatic).

the total of the evidence. The writer has not seen such a fracture shown in the *x*-ray: it would only exceptionally show if present. Such a fracture clinically amounts to nothing, comparatively speaking. The only importance of the lesion is that, owing to Dr. Bigelow's observation of one of these cases (he being then a widely accepted authority), the diagnosis came to be a popular one, especially in Boston, and, even at the time the writer was in the medical school, diagnoses of "stellate fractures" at the

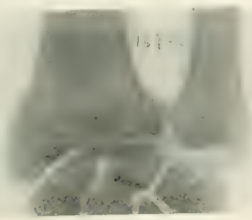


Fig. 554.—Fracture of radial styloid (also a chip off the radius at the back), confirmed by operation.

Fig. 555.—Transverse crack (*S* displacement) at point shown by arrow.

wrist or elsewhere were made in all sorts of cases, not one in twenty of which can have been such a fracture. As a matter of fact, apart from the rarity of these cases, the diagnosis is next to impossible, and the possibility of the occurrence of such fracture has undoubtedly been an excuse for neglecting proper examination of many minor cases of injury.

(*a*) *Transverse Cracks.*—These are far more common than the vertical ones. They occur from falls, and represent simply an incomplete form of the ordinary fracture. Whether they involve the *whole* thickness of the bone we cannot always tell; certainly they often seem to, judging by tenderness, and sometimes the x-ray shows the crack in the cortical

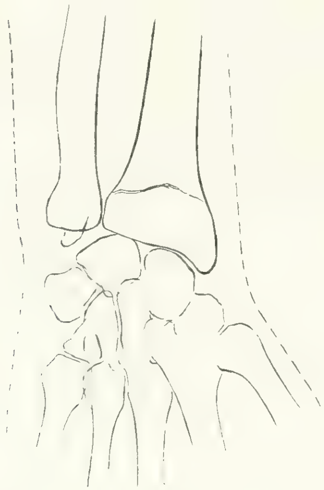


Fig. 556.—Fissure of radius, transverse (x-ray tracing).

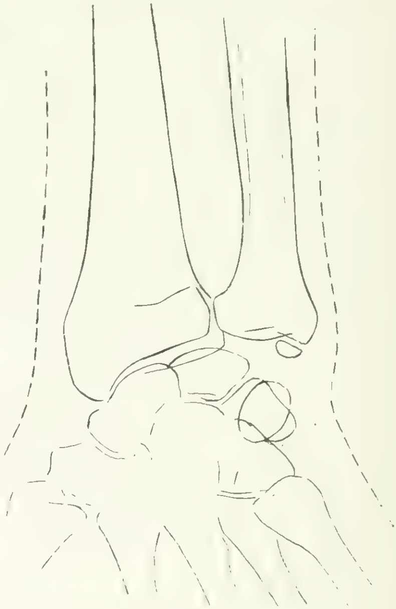


Fig. 557.—Fissure across inner portion of the radius only; fracture of the ulnar styloid process.

bone, both front and back. They show no displacement, and nothing more than a sharply localized tenderness. There is sometimes, not

Fig. 558.—Green-stick fracture of both bones at the wrist (just above the epiphyseal line). Displacement is typically backward; here also slightly outward.

Fig. 559.—Green-stick fracture of both bones; displacement backward (side view of same case as Fig. 558).

always, tenderness to pressure exerted in the direction of the long axis of the bone.

X. *Green-stick Fracture of Both Bones.*—Fracture of this "green-stick" variety is common in children. It usually occurs at like height

in both radius and ulna, slightly higher than the ordinary Colles' fracture.

This is a definite type of fracture, occurring particularly in small children, as a result of falls upon the hand. The fracture itself is a break across both radius and ulna at about the same height, anywhere in the lower quarter of the bone.

Fig. 560.—Green-stick fracture of both bones; fracture of radius had been completed before the case was seen.

Fig. 561.—Green-stick fracture of radius alone.

Clinically, the wrist from the radial side looks exactly like a Colles' fracture excepting that the silver-fork deformity looks a little high. On palpation we find readily that the ulnar head is not displaced in relation to the radius, and that there is a curve in the ulnar shaft.

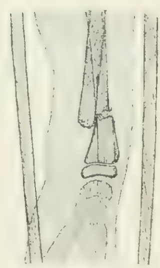


Fig. 562.—Sketch from x-ray plate of a case in which there had been a "green-stick" of both bones. The fracture of the radius had been completed in attempts at reduction before the case was seen. There was deformity as shown. Traction under ether with direct force gave better position, without overlap; proper use of pads gave perfect position eventually.

This fracture is to be reduced like any green-stick fracture, but here, more than almost anywhere else in the body, it is important to break away from the academic teachings as to reduction. This fracture, like every green-stick fracture, must *not be* completed if we can avoid it, but the bones must be pressed back to their former position, or even a little overcorrected. Any bone that will fracture in this fashion is soft enough so that we can press it back into a straight line, or even beyond a straight line, and so interlock the torn surfaces by jamming as to maintain the desired position, *without completing the fracture*, save by rare accident, and in any event without tearing across the periosteum. Treated in this way these fractures have *no* displacement and are far different from the loose fracture produced by completing the break, as to both treatment and prognosis.

XI. *Lesions of the Ulna.*—Fracture of the shaft of the ulna in connection with Colles' fracture is unusual.* It is apt to occur higher than the fracture of the radius, but there may be a breaking across just above the ulnar head. The displacement is in the direction of the radial displacement.

When the ulna gives way, there is little or no damage to the radio-ulnar ligaments.

XII. *Fracture of the Ulnar Styloid.*—This is the commonest of the fractures *complicating* the radial lesions. It has been long recognized as occurring, but its *frequency* was unsuspected until proved by the skiagraph. Percentages vary greatly. The writer found it in 18 out of 45 unselected cases in which the skiagraph was examined for the purpose. Other series run much higher percentages—up to nearly half

Fig. 563.—Separation of radial epiphysis (successfully reduced); fracture of ulna successfully reduced (later) by incision and suture.

Fig. 564. Photograph of same case as Fig. 563. Despite appearances, the deformity was of the ulna only; the radius had already been perfectly reduced (photographed *before* operation).

the cases of Colles' fracture. The fracture is usually near the base, and is apt to be nearly transverse. The displacement is downward and outward, and may be considerable in extent. The separation is probably due to the traction of the lateral ligament and not from direct violence or from pull on the triangular fibrocartilage. Union is usually by ligament only.

The only importance of this dislocation lies in the fact, pointed out

* The writer cannot agree with Beck, who considers fracture of the ulna at or near its head a common complication of the radial lesion. Except for Beck's plates, there are only five specimens or plates known to the writer showing this condition. The assumption that such lesion is the cause of loss of pronation and supination is inconclusive, considering the frequency of comminution of the radius through the facet with which the ulna articulates.

Separation of the ulnar *epiphysis* is well recognized as a complication of the fracture or of the separation of the radial epiphysis.

by Moore,* that the broken tip left behind may become entangled with the ligaments, so as to complicate reduction. The fracture *per se* cannot usually be diagnosed except by the *x*-ray, and, so far as results are concerned, the writer has never been able to convince himself that this lesion made the slightest difference.

XIII. *Fracture of the Ulnar Styloid* (*Alone*).—The ulnar styloid may be broken without other lesions of bone. This lesion apparently results purely from *abduction* strain. Clinically, it occurs from falls on the ulnar edge of the hand. I have seen two cases. The lesion is of little importance clinically. The course of repair differs in no appreciable way from that of simple "sprain" of the wrist. (See Fig. 569.)

Lesions of Ligaments.—The internal lateral ligament, attached to the ulnar styloid, may be torn away. The anterior radio-ulnar ligaments, as well as the posterior, are frequently more or less torn. That this is so is clinically obvious from the frequency of associated forward displacement of the ulna.

Fig. 565.—Fracture of the radius; fracture of ulna near the joint; much crushing of bone in the radius; marked outward and upward displacement and rotation; fragments freely movable; delayed union.

Fig. 566.—Comminuted Colles' fracture. Fracture of ulna across above the head; much displacement (*x*-ray *before* reduction).

The triangular fibrocartilage which runs from the base of the ulnar styloid to the edge of the radial articulating surface may be variously torn. This seems, from the dissections, to be a common lesion, and must *necessarily* occur if there is extreme ulnar displacement. Nothing more is known of its importance than that these cases with extreme ulnar displacement are apt to show some weakening in this region after bony union of the radius.

* Moore, of Rochester, N. Y., N. Y. Med. Record, 1880, xlii, p. 305.

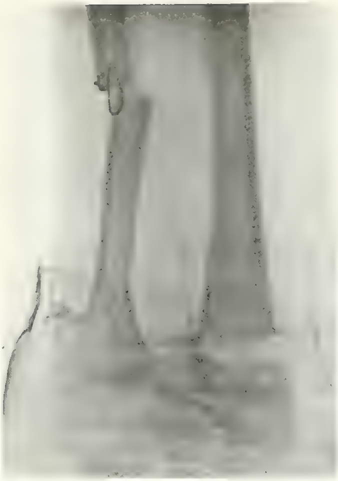


Fig. 567.—Colles' fracture, with fracture of the ulnar *shaft*. Colles' fracture reduced; the ulnar fracture wired.

Fig. 568.—Separation of the radial epiphysis (reduced); fracture of the shaft of the ulna.

Fig. 569.—Avulsion of the ulnar styloid from a fall on the hand, *without* Colles' fracture, but with a broken scaphoid (author's case).

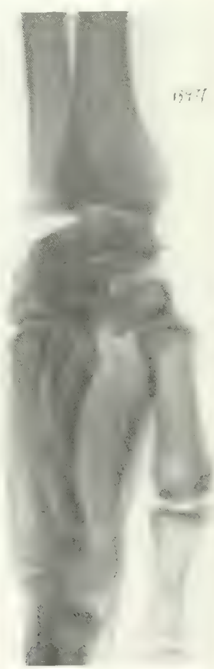


Fig. 570.—Same case (view from the side).

Lesions of Periosteum.—The stripping up of the periosteum, especially on the posterior surface, occurs in Colles' fracture, as it does in epiphyseal separation, though probably less constantly and to a less extent (Fig. 571).

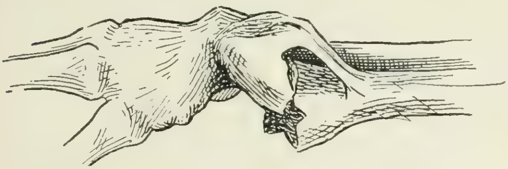


Fig. 571.—Fracture with backward displacement and backward rotation. Shows the stripping up of the untorn periosteum posteriorly (after Westbrook's plate).

Fig. 572.—Colles' fracture with compound luxation of the ulna and rupture of the ulnar nerve. Seen June 27, 1907, with Dr. O'Shea, house surgeon at the City Hospital (redrawn from sketch made at the time).

Injuries to Vessels.—These are rare, and the classic specimen of which the plate is here given seems to be almost unique. (See Fig. 497.)

Fig. 573.—"Traumatic arthritis." Transverse crack across radius without displacement, treated without fixation of the fingers; splints removed early. She rapidly developed total loss of power in the hand, extreme stiffness, and much pain. The x-ray shows the extreme bone absorption (with "penciling" of the lines of the cortical layer everywhere) characteristic of rheumatoid arthritis. Under treatment recovery was practically complete in about a year. The patient was a healthy woman in the forties, who never had had any joint troubles (case seen with Dr. F. F. Pike, of Melrose, Mass.; x-ray by Dr. Percy E. Brown).

Injuries to Nerves.—Injuries to nerves are uncommon, and are limited, substantially, to stretching of the ulnar nerve over the head of

the ulna, which, in fact, rarely occurs, and seems not to be of importance when it does occur. Once I have seen actual tearing of the ulnar nerve in compound Colles' fracture (Fig. 572).

Compound Fractures.—Compound Colles' fractures are rare, strictly speaking. That is, there is rarely any outward communication with the fracture itself.

Not uncommonly there is some tearing of the skin where the displaced *ulna* strikes, and now and then the ulnar head is thrust into this rent, making an indirect communication with the radial fracture.

I have seen perhaps half a dozen such; all were cleaned out thoroughly and did well, except the one shown in Fig. 574.

Fig. 574. Compound Colles' fracture with comminution and with a long spiral fracture line running upward.

Here and there we meet with cases in which there is extensive tearing of soft parts communicating with the fracture, in which the prognosis is mainly dependent on repair of nerve and tendon, and the bone lesion, so long as it remains aseptic, is of secondary importance.

In other cases—I recall two—the *radius* came through. In one the projecting end of the radial shaft (it came through alongside the flexor tendons to the thumb side) was ground full of cinders, and part of the surface had to be removed with rongeurs to get a clean wound. This case healed by first intention with a fair result.

Impaction.—The frequency of impaction in these fractures has been, *and must remain,* a matter of estimate. The skiagraph does not help us, and clinically it is very hard to say, even after reduction, whether a fracture was really impacted, or whether the muscles simply held the broken bone-ends entangled by their rough surfaces.

An impaction firm enough to offer great resistance to reduction is not common. On the other hand, fractures so loose as to permit of obtaining crepitus without anesthesia, without the use of much force, are very unusual indeed.

This résumé covers the lesions actually occurring in radius fractures at the wrist which are of any consequence. Apart from the alleged constancy of impaction, there is but one other common assumption as to the pathology which is wrong and which should be corrected; this is in regard to hemorrhage into, and adhesions of, the tendon-sheaths.

It would be unwise to deny that there may be hemorrhage into the sheaths, but so far as the records of exact observations go, hemorrhage is far more constant *outside* the sheaths, and we have no right to assume that the common swelling (see Fig. 579) about or even into the sheaths represents hemorrhage.

As to adhesions as a primary cause of stiffness and loss of motion, we have not a shadow of evidence. Personally, I believe such adhesions to be clinically negligible if they do exist, and I believe that the loss of motion here, as with most other fractures, is due to a shortening of muscles from fixation and disuse (plus the trauma), and to a shortening of fibrous structures about the joints, usually of later origin.

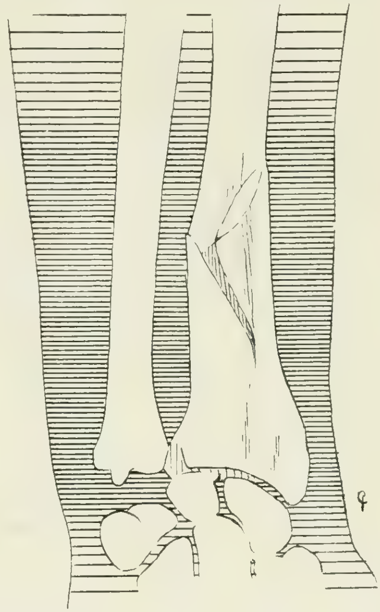


Fig. 575.—Sketch from x-ray of a similar lesion, in this case not compound.

The theory of tendon-sheath adhesions lies at the bottom of much of the advocacy of forcible breaking up and forced passive motion, which has done so much harm.

Symptoms.—The typical Colles' fracture causes only *partial* disability of the wrist and hand.*

There is displacement of the hand backward.

There is a fullness in the front of the wrist over the radius, and a fullness slightly lower down, on the back of the hand—the first produced by loss of the radial arch and by the pushing forward of tendons, etc., by the lower end of the upper fragment; the latter produced mainly by the prominence of the lower fragment itself, partly by blood and serous effusion in the soft tissues, or serum in the sheaths of the extensor tendons. (See Fig. 579.)

Fig. 576.—Diagram of the so-called "silver-fork" deformity.

There is a loss of the normal prominence of the ulnar head on the back of the wrist, with a corresponding fullness on the front of the wrist, a prominence caused by the displacement of the ulnar head forward to a position near the pisiform bone. This displacement is almost absolutely diagnostic of Colles' fracture.

The hand is usually held in partial flexion.

Seen from either side, the typical "silver-fork deformity" is easily

* There is a firmly fixed lay belief that there can be no fracture if the hand can be used, a belief responsible for a good deal of trouble.

recognized. This silver-fork deformity may rarely be counterfeited by swelling *not* due to fracture, but is *almost* pathognomonic of Colles' fracture (Fig. 576).

On closer examination we find a change in the relation of the styloid processes. The tip of the radius, instead of being lower than the ulnar tip, is at the same level, or even higher up. On feeling along the front of the radius the normal arch is found to be flattened out, and sometimes the lower end of the upper fragment can be felt. On feeling down the posterior surface of the bone it is usually possible to make out a ridge, which is the projecting edge of the lower fragment. A similar ridge is often to be felt on the *outer* surface (Figs. 577, 578).

Motion is relatively little interfered with, but the range of *extension* of the wrist is better than that of flexion. There is usually some tendency to *abduction* of the hand, as well as to backward displacement.

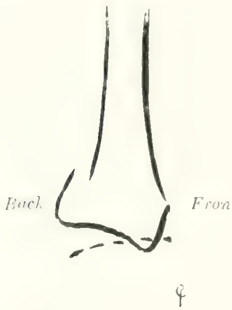


Fig. 577.—Backward rotation (diagram). The dotted line shows the normal slope of the joint surface.

Fig. 578.—Outward rotation from the front. The dotted line shows the normal outline.

Fig. 579.—Site of the rather common effusion seen in Colles' fracture into the tendon-sheath of the thumb muscles and the common extensor sheath.

At times this is so pronounced as to give an entirely different clinical picture from the classic one. An outward displacement of the hand *without silver-fork deformity* may be present, with well-marked prominence of the ulna *to the inner side*, as well as forward. These are the cases of so-called "abduction Colles." In neither this nor in the classic type is any crepitus to be made out, as a rule.

The foregoing describes the typical clinical picture of *well-pronounced* cases. The amount of displacement and the amount of bone destruction vary a good deal; we have cases varying through all degrees, from such as those described down to those in which a slight lameness of the wrist and slight swelling are accompanied with nothing more diagnostic than a line of tenderness running around the shaft of the bone.

These minor cases may not even show any abnormal position of the ulna. In such cases as this *absolute* diagnosis is not always easy.

In cases where there is any considerable displacement there ought to be no question as to the diagnosis.

The type of lesion of importance that is most often overlooked is the fracture in which the total *displacement* is not very great, though the *rotation* of the lower fragment *backward* may be very marked (Fig. 577). These cases, if seen when there is swelling present, show very little deformity; they show little change in the level of the styloids, and they may not show the characteristic ridges on the back and outer side. They do show localized tenderness, and they show a flattening of the radial arch and a dislocation forward of the ulna, which should be sufficient for diagnosis.

The question of the use of the x-ray in Colles' fracture deserves a word of notice. Save for cases apparently atypical there should be no necessity of waiting for an x-ray before reduction of the fracture. With moderate experience and skill a very fair estimate of the displacement and position may be arrived at*—an estimate quite good enough to guide our efforts at reduction, particularly because reduction is carried on in pretty much the same way regardless of exact details. The question whether or not there is comminution of the lower fragment, for instance, may, in a degree, affect prognosis, but will hardly change the procedure of treatment. So, also, the question whether or not there is a fracture of the ulnar styloid makes no difference in the treatment of the case, while the delay of a day or two waiting for a skiagraph not only is productive of discomfort to the patient, but probably also affects the result unfavorably.

Fig. 580.—Colles' fracture on the left. Note the loss of backward prominence of the ulnar head at the wrist.

It is the writer's rule to wait for an x-ray *only* in cases where the displacement is so slight as to raise the question whether any *profitable* reduction could be carried out.

The severer cases are to be reduced as soon as seen.

* It is not too much to say that an expert examination is worth *more* than the x-ray as to position, *unless we have two views taken*. Consideration of Figs. 515 and 516 will elucidate this. In these cases the ordinary view tells us practically nothing as to displacement—trained fingers would tell the whole story.

The time for an x-ray in such cases is *after* reduction, to test the success of reduction.

Treatment.—All cases should be treated under an anesthetic if possible. Full surgical anesthesia is unnecessary. Primary ether* is sufficient, and nitrous oxid is a perfectly satisfactory substitute. All

Fig. 581.—Ulnar head shows only slight prominence in pronated position.

Fig. 582.—Ulnar head is displaced sharply forward on supination. There was in this case an obvious entanglement of the sharp end of the broken ulnar styloid in the ligaments (note the visible dimple). Attempts to reduce this entanglement failed (same case as shown in Fig. 580, but photographs reversed in reproduction).

that we need is the opportunity of a half-minute for manipulation without pain to the patient and without severe muscular contraction.

Fig. 583.—Grip No. 1 for reduction of Colles' fracture.

Even if the patient is willing to stand the pain, his muscular resistance and the effort of the operator to avoid inflicting pain unnecessarily

* That is, etherization produced by rapid full respirations to a stage of anesthesia with some relaxation of muscles. In such anesthesia consciousness may not be lost at all; sensation of pain is, however, abolished for a long enough time to permit reduction.

almost always result in inferior work. Anesthesia is, therefore, almost essential.

Before reduction we must get a clear notion of the following points:

Fig. 584.—Grip No. 2.

Fig. 585.—Grip No. 3.

(*a*) The amount of total backward *displacement* of the lower fragment. (*b*) The amount of *rotation* of the fragment. (*c*) The amount of outward displacement or rotation. (*d*) The presence of such thickening

or broadening as would suggest comminution. (*e*) The extent of displacement of the ulna and the probability—or the reverse—of an entangling of the stump of the ulnar styloid in the ligaments.

Fig. 586.—Grip No. 4.

Then we may proceed with the reduction.

An assistant gives countertraction at the elbow or axilla. The

Fig. 587.—Grip No. 5—only to be used where a good deal of force proves necessary, never for the first trial.

surgeon may use any of the grips illustrated in Figs. 583–588. The choice depends somewhat upon the amount of swelling present and the ease with which the fragment can be clasped, somewhat upon the

size of the patient's hand in proportion to the surgeon's. More than all it depends upon the habit and convenience of the surgeon. The writer's usual routine is as follows:

(1) Grip 1 is used, with strong traction to start the loosening of the fragments.

(2) Then grip 3, until any impaction present is entirely loosened.

(3) Then grip 6 is assumed, and circumduction of the hand in *both* directions is carried out (Fig. 588), in order to untangle the possibly entangled ulna,* then the hand is brought over into sharp *flexion,* with a shove on the back (grip 2), and, finally, the displacement as a whole

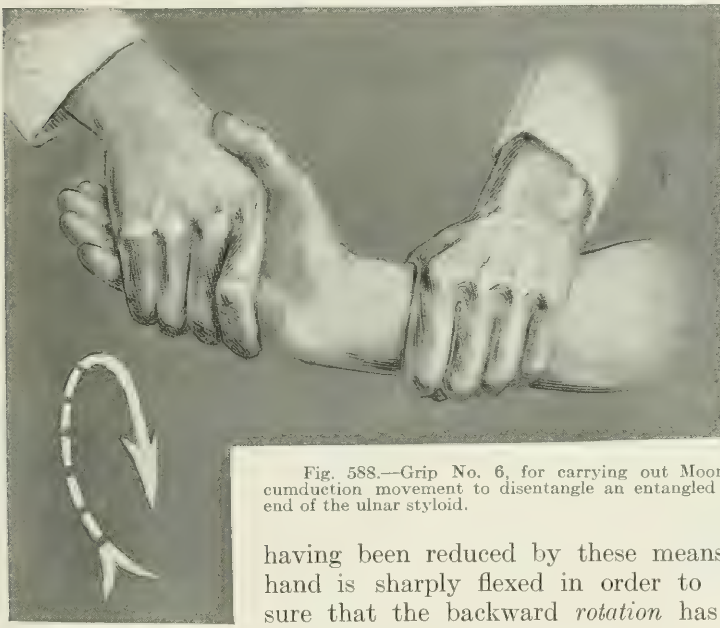


Fig. 588.—Grip No. 6, for carrying out Moore's circumduction movement to disentangle an entangled broken end of the ulnar styloid.

having been reduced by these means, the hand is sharply flexed in order to make sure that the backward *rotation* has been overcome.

If these manœuvers have been carried out properly, there should be little tendency to any recurrence of deformity.

Other grips shown give more *power* in reduction when this is needed.

The position should be verified by a careful reëxamination of all landmarks. It happens not infrequently that some *outward* displacement is first recognized at this examination: this must be corrected by traction, adduction, and direct pressure.

All this seems like a complicated procedure, and does, in fact, require some experience in the various grips and manipulations, but in actual practice it takes a very short time indeed.

* After Moore's prescription, N. Y. Med. Rec., 1880, xvii, p. 305.

As soon as the fracture is properly replaced anesthesia can be stopped. The wrist is held by the operator until the patient recovers full consciousness, which, with proper *primary* ether anesthesia, should not be over two or three minutes, and then the application of splints is carried out, with the patient again conscious and suffering very little pain.

A number of forms of splint have been used, but, in fact, the form of splint is relatively unimportant if the points of pressure to be secured by pads are properly borne in mind.* Pressure made on the fragments means, of course, *not active pressure,* but simply the securing of the fracture against accidental disturbance.

The points to be so used for pressure are as follows:

(*a*) The arch of the radius, opposite the lower end of the upper fragment in front; (*b*) the lower end of the ulna in front, just above the joint; (*c*) the back of the hand; pressure on the back of the hand is equivalent to pressure on the lower end of the lower fragment, to which the hand is firmly attached by ligaments.

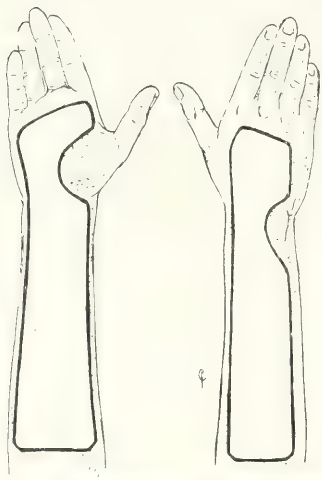


Fig. 589. Pattern of splints, of light splint wood, as used for some years by the writer.

There are also points of pressure which must be carefully avoided, viz., the back of the radius at or above the fracture, the back of the ulna at any point, and the thenar eminence.

In order to avoid pressure on these points, and in order to give support to the pads by which we obtain pressure where it is wanted, both anterior and posterior splints are needed. Only in fractures without displacement—or substantially without displacement—is it wise to sacrifice support and to depend simply upon the strapping or upon strapping with the short dorsal splint, though such simple splinting has often been advised.

Rigid splints for the first few days do no harm and may avoid re-displacement. The form of splints used by the writer is shown in the

* All the older forms of splint, from Nélaton down, which depend on extreme adduction of the hand for correction, have been discarded. Such splints insure discomfort, and often entail some disability from stretching. In fact, the whole story is one of *proper reduction,* and such splinting as will minimize the chance of *accidental* displacement. Muscle pull is ordinarily unimportant, and we could not work against it effectively if it were important. In case there is much bone-crushing, for instance, I have never seen a case where attempts to hold the uncrushed portions apart were in the least degree successful. (See Fig. 590.)

accompanying illustrations. The majority of surgeons today use splints of something the same general type.*

These splints are padded in the usual way, with sheet-wadding strapped in place, and with pads cut to correspond with the special areas of pressure. The best material for these pads is the loose yellow "saddler's felt," which may be cut readily, is elastic, and holds its shape much better than a cotton pad. These pads are best strapped on the splint with the sheet-wadding covering.

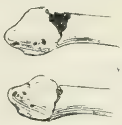


Fig. 590.—Comminution of a portion of the bone to small fragments leaves a gap (upper figure). In such case the most skilful reduction and care cannot prevent approximation of fragments; the best result attainable will include a closing of this gap by rotation backward of the lower fragment (lower figure).

Considerable thicknesses of felt can be used without discomfort and with almost no risk of trouble from pressure. The one point at which the danger of pressure is considerable is over the spur at the bases of the second and third metacarpals, on the back of the hand. Sloughs here are very easily produced, even with felt padding, and where this spur is prominent, it is well to cut a hole in the splint. (See Fig. 592.)

When the splints are applied, they must be fastened in place by adhesive plaster, holding them in their relative position, and, for part of the circumference, adhering to the skin. This is the only way to prevent rotation and slipping of the splints. It is permissible to shave a hairy arm before applying the plaster, but not permissible to apply a sheet of cotton under it to avoid sticking. Adhesion to the skin is exactly what is wanted. These adhesive straps should *not* be the means used to produce pressure by the pads. This pressure is obtained by the succeeding layers of bandage. After the plaster straps are put on, a roller of sheet-wadding is wrapped around the arm (splint included), and then the bandage, not of gauze, but a muslin roller 1 or 1½ inches wide, is to be applied snugly enough to produce whatever pressure is

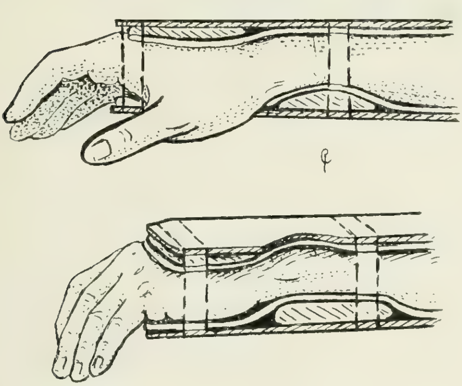


Fig. 591.—Application of pads (felt or cotton "sheet-wadding"). There is a pad under the arch of the radius, one under the lower end of the ulna, and a pad which lies on the back of the hand or may extend onto the back surface of the lower fragment.

* The Levis or other molded splints, while serviceable, are not much used by those expert in fracture work because of the difficulty of fitting (exactly) the individual case.

desired. Excess of local pressure is indicated by persistent local pain; too much general constriction or local pressure on the veins is indicated by blueness of the hand and by swelling of the veins and a slowed return of the circulation.*

For purposes of appearances it is well to *wet* the roll of bandage before applying it. This makes a smoother bandage and one which soils much less readily, but it has the disadvantage of some shrinking when it dries, which must make us a little cautious in using it.

After the bandage is applied the hand should be put in a sling which supports the forearm and wrist, but not the hand. The hand should be in a position of semipronation. The sling should be so arranged that the wrist is as high as the elbow or a little higher. The bandage must be inspected after the hand is slung up to make sure that the upper edge, whether of plaster or bandage, does not cut into the arm or impede circulation.

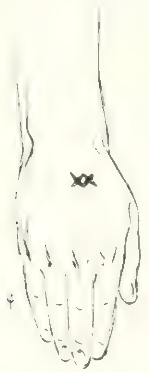


Fig. 592.—The crosses indicate the point of projection of the bases of the second and third metacarpals. We must have no pressure in this region, even if it is necessary to cut out a hole in the posterior splint (as I have repeatedly done) to avoid it. If we are careless, sloughs are liable to develop at this point in certain cases.

This is the usual method of doing up such a case and serves in nearly all instances.

There are a few cases of simple *crack* of the radius or of simple cross-break with little or no displacement (like some of the "automobile" fractures of the wrist), which do not need so much apparatus and which may perfectly wisely be put up with a single splint. A short dorsal splint may be used—a splint no wider than the radius—and slightly cut out to avoid pressure on the head of the ulna, or an anterior splint may be used, of the Bond, Carr, Nelson, or Bolles type. These are excellent rest splints, more comfortable than the posterior splint, though not very well adapted to accurate fixation of fragments.

Certain good surgeons, notably Moore,† of Rochester, Roberts,‡ of Philadelphia, and a few others, have boldly advocated the *routine* treatment of Colles' fracture (after proper reduction) with a simple circular band of adhesive plaster or with such a band reinforced with a short (3 inches or so) dorsal splint, with or without accessory special pads.

There is no doubt that in the hands of a thoroughly competent

* This is tested by pressing on the finger-nail until it goes white, then suddenly removing the pressure. The rapidity of return of the pink color is a measure of the sufficiency of the circulation. Numbness is apt to be from poor circulation; nerve pressure is more apt to show itself as pain.

† Moore, *loc. cit.*

‡ Roberts, in his Fracture of the Lower End of the Radius, etc., P. Blakiston Son & Co., 1897, p. 75 and elsewhere.

surgeon, with *proper coöperation* of the patient, this method is adequate, and guards against overimmobilization. But, until damage suits become less popular as a means of blackmail, and until the courts acquire the habit of closer discrimination as to contributory negligence, I am not ready to recommend the method.

AFTER-TREATMENT

These fractures, like all fractures of the limbs, should be inspected the next day. In the absence of some special doubt it is not necessary to remove even the bandage, but in these wrist fractures we should make certain regarding the following points:

(*a*) Swelling of the hand.

(*b*) Numbness or paresthesia of hand or fingers.

(*c*) Cyanosis.

(*d*) Amount of pain (pain in reduced fracture should not ordinarily be very severe after a few hours).

(*e*) Complaint of general discomfort from pressure.

(*f*) Complaint of *localized* pain at or near any point of *special* pressure.

This last complaint should be regarded as an *absolute* indication for cutting down the apparatus immediately. If this is done, the danger of sloughs of the back of the hand, over the base of the second and third metacarpal, such as the writer has seen follow neglect of such precaution, will be entirely avoided, or, at worst, minimized. A very considerable pressure may be borne for twelve to twenty-four hours without permanent damage.

So far as the presence of swelling and cyanosis is concerned, it is a question of degree. We must not expect in any fracture to be able to apply efficient apparatus without any interference with the circulation. In these wrist fractures, if we can keep them sufficiently free from swelling to avoid any interference with finger motion or any considerable discomfort, we do sufficiently well.

After this first inspection the patient should begin, if he has not already begun, to keep the fingers limber by passive motion, and more particularly by persistent active motion (not *use*). At no time should we allow the fingers to stiffen in the least, even if motion is slightly painful.

The splints should be removed *entirely* for inspection after three to five days more. In cases where the tendency toward recurrence is very slight, we may omit the anterior splint after four to six days. The same pads are reapplied, but they are made thicker, as they are now held with straps only for counterpressure.

The majority of cases may wisely be put on the single splint at the third, if not at the second, dressing. That is between five and ten

days after the accident. It is wise to do this as soon as possible, because even the best anterior splint does somewhat interfere with full flexion of the fingers. Within two weeks some mobility should be given, not only to the fingers, but to the wrist. We may discard the splint, or we may retain it merely as a protection, strapping it on loosely. Only in rare cases of delay in union, in cases with very great damage to bone and soft parts, can there ever be need of anything more than a *protective* splint after two weeks.

When the splints are removed, a wrist strapping of adhesive plaster is substituted for them. This is put on for a width of two to three inches upward from the wrist-joint; under it are put pads corresponding to the arch of the radius and to the front surface of the lower end of the ulna. This strapping should be changed every few days and kept on until we are willing to begin actual use of the hand. This will be, according to the case, from three to five weeks after the receipt of the injury.

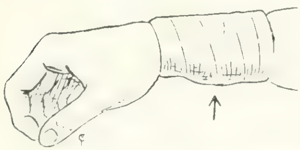


Fig. 593. Supporting dressing: circular bandaging with adhesive plaster. The arrow points to a felt pad under the arch of the radius.

When this adhesive plaster is discarded, it is well to support the wrist with a leather wrist-strap, fastening with one or two buckles, to be worn until the patient feels no further need of the support.

Results.—The important thing to remember is that bad results, *so far as function goes*, are far more apt to be the result of bad treatment than a result of the injury. In few instances has surgery inflicted so much unnecessary damage as in the treatment of Colles' fracture and of the related lesions. If such a case is left unreduced and the patient is allowed to consider it a "sprained" wrist, most unsightly deformities may result, but *function* is usually almost perfectly restored. There is, at most, some weakness, but not the stiffening of the fingers which so often resulted from the well-meant treatment so carefully carried out a generation ago.

Fig. 594.—Leather wrist-band, worn during convalescence, and often a comfort for some time after recovery. The band should have two straps.

Almost without exception it is possible, as we now know, to secure efficient reduction, to avoid recurrence of deformity, and *at the same time* to avoid stiffness. The avoidance of stiffening consists simply in never giving a chance for the fingers and wrist to stiffen. We should so treat these fractures that late massage, passive motion, and the "breaking-up" of so-called "adhesions in the tendon-sheaths" shall not be called for. If we *avoid* stiffening due to unwise fixation, the disabilities resulting from Colles' fracture, and the allied lesions, are almost entirely confined to a weakness of the *ulnar* side of the

wrist, due to an imperfect replacement of the luxated ulnar head, and to an imperfect repair of the torn ligaments.

So far as the radius is concerned, we may have some limitation of flexion of the wrist, with a corresponding abnormally free hyperextension, or a limited adduction, with a tendency to abduct too far, all due simply to a change of plane of the articular surface;* none of these factors are productive of any special trouble.

The great majority of broken wrists *which do not stiffen* are function-

Fig. 595.—Bilateral Colles' fracture. Shows how poor an anatomic result may give excellent function. Both these hands were normal as to function.

ally as good as new within a year of the injury. Secondary arthritis (Fig. 573) is rare.

Deformity.—All this has nothing to do with the deformity. It has been said, on excellent authority, that no wrist which does not show at least *some* displacement of the ulnar head, as compared with the other side, has ever been broken. There are exceptions to this rule, but it is a fact that every fracture in this region *in which there has been dis-*

* Dr. J. C. Munro has appreciated the fact that rotation, rather than displacement, accounts for both widening and abduction.

placement, does show in some degree some of the following deformities, however well it has been reduced:

1. Backward displacement of the lower fragment.
2. Backward rotation of the lower fragment.
3. Outward rotation of the lower fragment, with consequent *broadening* of the wrist.
4. Shortening of the radius, with consequent change in the relation of the styloids.
5. Forward, or inward and forward, displacement of the ulna.

In most instances these displacements are present in so slight a degree that the wrist shows no obvious deformity, but the displacement of the ulna, the backward rotation of the lower fragment, and the broadening due to the outward rotation (see Fig. 578) may almost invariably be made out without difficulty on careful examination.

Fig. 596.—Old Colles' fracture with outward displacement and shortenings enough to bring the radial articulation above the end of the ulnar head. Good function. (*x*-ray tracing.)

There are cases in which even unsightly deformity is entirely unavoidable. Most commonly, this is due to—

(*a*) Extreme displacement of the ulna with weak ligamentous repair, allowing a forward displacement, progressive on use.

(*b*) A crushing of the posterior or outer surface of the bone into fine fragments, leaving an unfilled gap between the bone-fragments after reduction, a gap which *can not* be kept open until healing is complete by any practicable form of splints.

(*c*) Comminution of fragments, admitting of little actual fixation by splints. This condition has no necessary relation to delayed union.

In all the above conditions, even in cases with no more than the usual primary displacement, we may get astonishingly poor results as to shape, in spite of the greatest care.

Fortunately, these conditions are not common.

Extreme displacement of the ulna is associated with extreme trauma or with poor reparative power.

The crushing-up of bone is apt to be an obstacle only in very old patients or feeble ones, in whom the bone structure has been greatly changed and weakened.

As a rule, adequately treated cases show, in the end, only a slight flattening of the radial arch and slight forward displacement of the ulna.

Operative Treatment.—Nothing is simpler than to do an osteotomy of the radius from the back or from the outer side, and to correct displacement. Many such operations have been done.

Some should be done. Certainly bad results from epiphyseal separation in children should be corrected.

As to the general run of cases, I should say that *unsightly* deformities should be corrected, unless in the aged.

As to the rest, it should often be left for the patient to decide how much he cares about a little deformity that gives no disability.

Deformities can be corrected, but we can rarely hold out any honest hope of permanent relief as to function.

LUXATION OF THE ULNA AT THE WRIST

There is a good deal of literature devoted to this luxation,* but much of it is valueless for our consideration now, for two reasons: first, because a great many dislocations of the ulna backward are of "congenital" origin, or are due to a short radius or to other unusual causes; and second, that a great many luxations of the ulna forward and inward are really simply complications of Colles' fracture. These last are truly luxations, and in many instances the luxation counts for more in results than the fracture, but it is distinctly a secondary result, and hardly to be classed with independent luxations.

Allowing, however, for these two sources of error, there is sufficient evidence to accept the existence of uncomplicated backward dislocations of the ulna due to trauma, and of certain rare forward luxations without fracture.

Of uncomplicated *inward* luxations, I have some doubt.

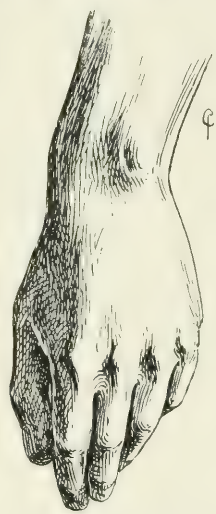


Fig. 597.—Backward luxation of ulna (alone) at wrist (sketch after Rognetta's plate).

LUXATION OF THE ULNA BACKWARD

Our knowledge of this lesion comes from Desault, who gives the following cases, which seem conclusive.

Case of a child of five years, whose arm was overpronated as the child was lifted from a couch by an adult. This case Desault saw, and reduced the bone by direct pressure forward on the ulna, with an attempt

* In the main, this literature is so old as to be a bit doubtful.
Vallas (Bull. Soc. de Chirurgie de Lyon, 1904, and Lyon méd., 1904, ciii, p. 885) reports a modern case.

at separation between the two bones and with forced supination carried out by an assistant.

Immediate reduction was followed by permanent recovery.

Desault also records cases of a child of two years with a like condition but without a history, and of a man of forty with a history of an injury by overpronation three months before. Reduction failed in this last case.

His other cases strike me as doubtful.*

Symptoms.—From the data at hand this luxation seems to be accompanied by a good deal of disability, including a loss of power in the fingers, which is not altogether easy to understand.

The wrist is held in pronation, supination is entirely impossible, and the fingers are usually held extended or semiflexed, with the wrist extended.

The hand is uniformly *adducted*. There is an obvious prominence of the head of the ulna at the back of the wrist, with not only a displacement backward, but a displacement outward as well, so that the head of the bone *crosses over* to some extent onto the back of the radius. This results in an obvious narrowing of the wrist (Fig. 597).

In the old unreduced cases there would seem to be little improvement of function, in unbelievable contrast to the *perfect* function of the "congenital" cases showing like deformity.

Diagnosis.—The diagnosis of these cases presents one difficulty, namely, the discrimination between injuries of a congenitally abnormal

* Rognetta (Archive gén. de médecine, 1834, Series II, vol. v, p. 397) describes certain other clinical cases. One was in a man of sixty-eight whose hand was twisted from overpronation, and who showed a displacement of the ulna backward and outward so far that the tip of the ulna was opposite the semilunar bone. Supination was impossible, the fingers useless. Was first seen at two months, reduced according to Desault's method; during reduction supination and the finger motions became possible, but the displacement recurred; further treatment was not carried out on account of outward circumstances.

The second case was apparently typical, following an injury of the bone some time previously. In this case also reduction was possible, but recurrence was immediate. Further treatment was not carried out. This case followed an acute rheumatism, and the question is as to whether this was not purely a pathologic dislocation. Rognetta also speaks of a case of a wood-sawyer, a negro, in whom there was marked enlargement of the bones of the forearm and a laxity of ligaments that permitted ready luxation of the ulna backward, and an equally ready replacement. He regarded this as a matter of loosening of ligaments due to strain, but there is a question if this was not also a pathologic luxation.

He records also the case of a washerwoman of thirty-four years of age who had suffered an injury six days previously by overpronation in wringing clothes. This was the result not of overaction of her own muscles, but because another woman with whom she was working twisted more strongly than she. The hand was *adducted* and flexed, and was held in pronation. There was obvious deformity, as in the other cases. Reduction was accomplished as previously described. There was no recurrence of the displacement, and at the end of two weeks all motions of the wrist and hand were normal.

He cites one more case, of two months' duration, successfully reduced, but held only by forced supination and by special padding. This case, after a month of such fixation, is said to have staid reduced, and to have had good motion.

wrist and the results of the original trauma. As an illustration of this may be cited the following:

Miss M., nurse, aged thirty, seen by the writer with Dr. E. H. Nichols February 10, 1907. Recent injury to the left wrist. Clinically, the wrist showed a good deal of disability, and objectively there was a well-marked backward dislocation of the ulna at the wrist. The wrist is said to have been abnormal in shape since an *injury* in childhood. *x*-Ray plate shows a curve outward of the radius, with an obliquity inward of the lower articular face of the radius, with a subluxation of the wrist inward, with a change in the shape of the carpal bones, and with the ulna a half-inch shorter than on the other arm, with its lower head dislocated backward. There is no semilunar facet on the radius, as seen in the *x*-ray plate. Reduction under ether proved impossible (Fig. 598).

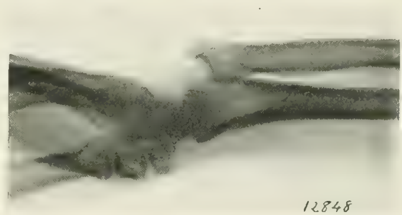


Fig. 598. Backward luxation of ulna alone. Fresh injury, but also history of old injury (courtesy of Dr. E. H. Nichols). Probably a congenital luxation.

This is a case in point, inasmuch as it is not only very improbable that the recent injury produced any displacement, but also rather improbable that any injury in childhood could have produced these changes—changes which agree entirely with those seen recently by the writer in two other cases known to be *non-traumatic* and *probably congenital.*

Fig. 599.—Desault's reduction of backward luxation of the ulna. The thumbs *shove* the bones apart.

Treatment.—Desault* has outlined what is probably the most efficient reduction manœuver. The wrist is grasped by the two hands, one on the outer, one on the inner, side, in such fashion that the two thumbs press at the interval between radius and ulna behind, and the fingers are pressed in the corresponding interval in front. An effort is thus made to separate the radius and ulna laterally, while an assistant forces the hand into supination. The operator at the same time aids in forcing the ulna forward and the radius back. If the case be recent, reduction is accomplished with a snap, and seems not to tend to recur. In older cases there is a tendency to recurrence, and fixation in the supinated condition will be necessary for several weeks, with only gradual resumption of pronation.

*Journ. de Chirurgie, vol. i, No. i, p. 78, in an excerpt of an address of his, never published in full.

Results.—In recent cases results are recorded as perfect. The results of the untreated dislocations seem to involve considerable permanent disability, particularly from inability to supinate. According to Desault, reduction of the old luxation, followed by long fixation, gives good results, including the ability to supinate. There seem to be no other cases than his to show this.

Chronic Backward Luxation of Ulna

Chronic backward luxation to a *slight* extent is apparently not very uncommon as a result of overwork in childhood. The writer has seen several cases, always accompanied by a good deal of hypertrophy of the lower end of the ulna, not always accompanied by the deformity to the radius to which Madelung's name is attached. These cases show disability only in loss of hyperextension and sometimes in slight overtiring at work.

Here and there in cases of Colles' fracture with *forward* displacement, or even without very much forward displacement, we may find *subluxation of the ulna backward.*

In one instance, as a result of old Colles' fracture, there was shorten-

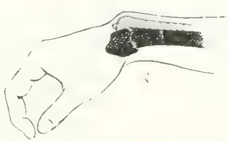


Fig. 600.—Luxation of ulna backward, with anterior displacement of radial fracture (radius in black).

Fig. 601.—Dislocation of the ulna inward can only come from separation of the ulna from the radius—*divergent* luxation.

ing of the radius and a luxation of the ulnar head back and down over the carpus so far that extension of the wrist was interfered with. A resection of the head of the ulna was done, with good result.

Madelung's Deformity

Madelung's deformity is described by him as a distorsion of the radius at its lower end, with ulnar displacement backward, a result of the strain of overwork at a time when the bones are still soft. Fig. 487 gives the character of the deformity.

LUXATION OF THE ULNA INWARD

In case of this injury also there is some question whether it occurs apart from fracture. The following case may be accepted on the authority of Dupuytren and Rognetta.

Woman of twenty-one, washerwoman, who had had a blow on the wrist recently, but had had a deformity of the wrist dating back some

years. There was a broadening of five or six lines, and the ulna displaced inward, that is, away from the radius, and a little forward. Supination was impossible. There was loss of motion in flexion of the fingers, and the hand was slightly abducted. Reduction temporarily restored the motion of supination, which was again lost when pressure was taken off and the luxation recurred.

LUXATION OF THE ULNA FORWARD

The possibility of forward luxations of the ulna, apart from Colles' fracture, is somewhat doubtful. There are two dissections on record, one by Palletta, one by Desault, which show beyond doubt the possibility of the luxation. In one case no mention is made of the search for an old fracture; in the other, its presence is denied, but no details are given. Both were dissecting-room specimens without history.

Thon* gives a case that seems beyond question. The patient was a man of fifty; he had hold of a rope by which his hand was pulled over the branch of a tree and into sharp supination. Pronation was lost; he showed a very *narrow* wrist, with the ulna prominent in front. Reduction was by extension, traction, and pronation, after direct pressure failed.

It is in the cases with marked displacement of the ulna forward that we are apt to get "compound Colles' fracture," consisting, in fact, of a compound ulnar luxation accompanying the Colles' fracture.

The cause given for the isolated ulnar luxation is oversupination; inability to pronate is alleged as a result. In the common cases where the luxation accompanies the fracture there is no trace of such loss of ability to pronate.

Diagnosis.—Absence of the prominence of the ulna at the back of the hand and the presence of a rounded thickening, covered by the soft tissues of the ulnar and other flexors on the front of the wrist, just above the pisiform, are conclusive and sufficient evidence of this luxation. The whole look of the wrist from the ulnar side is entirely changed, as may be seen by Fig. 580.

Save in the rare cases where there is entanglement of a broken styloid process in the ligaments, there is no difficulty in reducing this luxation, but the tearing of ligaments is so great that redisplacement to some extent is almost inevitable. Even if the position be long maintained in splints, there is a marked tendency for the strain of work to produce some recurrence of the displacement.

Results.—Where there has been great tearing of ligaments and displacement, some weakness usually remains, most noticeable in motions involving forced pronation. There is no limitation of motion and no disability due to the deformity as such, in the ordinary run of cases.

* Deutsche Zeit. f. Chir., Bd. lxxxiv, 1906, 257.

RECURRENT LUXATION OF THE ULNA

A number of years ago there came into my care a young girl who had, as a result of trauma, a slipping of the ulna on the radius with every movement of supination. She was suffering severely from ulnar neuritis, as a result of the constant irritation. Operative treatment was declined; mechanical treatment failed on account of the intolerance of the damaged nerve to pressure. In this case there had been a Colles'

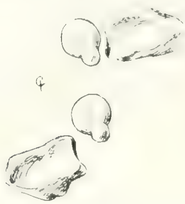


Fig. 602.—Diagram of wrist in supination and in pronation. Shows the falling away of radius from ulna in supination in recurrent luxation of the ulna (diagram).

Fig. 603.—Recurrent luxation of the ulna. Sketch from x-rays. The continuous line shows the original condition, the dotted line the position (corrected by osteotomy) that by tightening the radio-ulnar ligaments prevented the recurrent luxation. (Courtesy of Dr. Geo. H. Monks.)

fracture. Recently I examined, with Dr. G. H. Monks, a case similar in all respects, except for the neuritis.

This latter case was practically cured by him by an osteotomy that in effect tightened the radio-ulnar ligaments (for mechanism, see Fig. 603).

I do not know that the lesion has been described in the literature. Evidently there is an abnormal laxity of some or all of the radio-ulnar ligaments. I have seen many cases where there was a little looseness here after Colles' fracture, but ordinarily it is of no consequence as a cause of weakness, and gives no pain.

CHAPTER XVII

INJURIES OF THE CARPUS

Anatomy.—No injuries in the body need more accurate knowledge of *anatomy* for their proper diagnosis than those of the carpus. Without such knowledge the *x*-ray is more of a trap than a help.

There are in this region various anomalies—in the carpal bones themselves and in the occurrence of inconstant sesamoids. Pfitzner, of Strassburg, has written of these in a monumental work (Beit. z. Kenntniss d. menschl. Extremitätenskeletts, Morpholog. Arbeiten,

Fig. 604.—Landmarks of the carpus from the side. The outlines of the scaphoid and magnum and semilunar are seen; their relation is shown in the small explanatory sketch; note the obliquity of the scaphoid down *and forward* (shown by the heavy line). The faint outlines of the trapezium (*b*) and the pisiform (*a*) have been accentuated.

Fig. 605.—*x*-ray of normal carpus from the front. All the bones are to be made out; the pisiform partly overlaps the cuneiform; trapezium and trapezoid overlap, and scaphoid and semilunar partly cover the head of the os magnum.

Schwalbe, 1895, vol. iv, and in Zeit. f. morph. Arbeiten, Schwalbe, 1900, vol. ii, p. 365).

Dr. T. Dwight's "Variations of the Bones of the Hand and Foot," Lippincott, 1907, covers much of the ground and is more accessible.

LUXATIONS OF CARPUS

We have:

A. Dislocation of one row on the other, with or without scaphoid fracture.

B. Luxation of single bones, with or without fracture.

Dislocation of the Distal on the Proximal Row

This may result from severe falls on the hand in extension (rarely in flexion) or from direct violence. Frequently the injury is associated with fracture of the scaphoid; in a very few cases it is compound.

The displacement seems pretty uniformly to be backward displacement of the distal on the proximal row.* In the compound cases such injury, especially if associated with fracture, should commonly be easy to make out, and the bones may readily be replaced. In such cases as are not open to direct inspection the injury is marked by swelling.

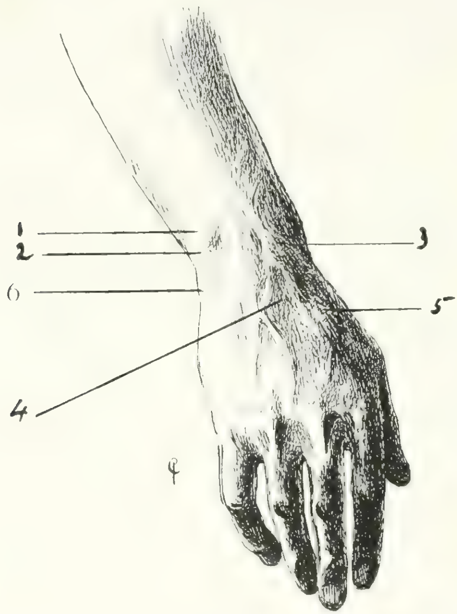


Fig. 606.—Landmarks of carpus: 1, Ulnar head; 2, ulnar styloid; 3, radial styloid; 4, position of os magnum—a deep hollow; 5, bases of second and third metacarpals; 6, lower edge of cuneiform.

The author has had no experience with these cases just at the time of accident, nor are there recorded data of such cases in the literature.

In only one case was there any question of reduction of a fresh luxation. This case was seen after a week. There was obvious, though not great, displacement of the hand backward. There was thickening and tenderness, especially about the scaphoid. The pro-

* In a measure this displacement is rotatory in that the displacement of the cuneiform seems usually incomplete.

Codman (Ann. Surg., June, 1905) has described the fracture luxation cases as scaphoid fracture "with dislocation of the semilunar forward." So also Destot (Bull. méd., 1905, xix, 1033) and J. A. Blake (Ann. Surg., 1901, xxxiv, 297).

jection of the lower row of carpal bones at the back could be felt, though not very clearly. There was loss of motion, particularly of extension

Fig. 607.—Fracture of scaphoid only (same case as Fig. 608, right hand).

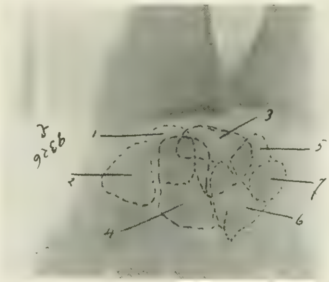


Fig. 608.—Left hand of same patient. Fracture of scaphoid, with dislocation of the distal row of carpal bones backward: 1, Scaphoid, proximal fragment; 2, scaphoid, distal fragment; 3, semilunar; 4, os magnum; 5, cuneiform; 6, unciform; 7, pisiform.

x-Rays of these carpal injuries are often very confusing, even with the best x-rays.

and abduction. The diagnosis was made and confirmed by the skiagraph. (Cf. Fig. 621.) Under ether strong traction, direct pressure, and rocking motions brought about a reduction, with restoration of normal motion. The final result was admirable, with practically perfect function, though the fractured scaphoid is presumably only united by fibrous tissue. There was no tendency to recurrence.

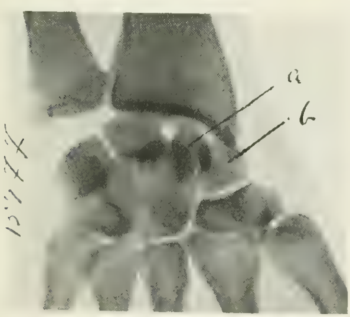


Fig. 609.—Dislocation of distal row of carpus backward. Fracture of scaphoid with great displacement: (*a*) Proximal fragment; (*b*) distal fragment. There is also a partial separation of the ulnar styloid.

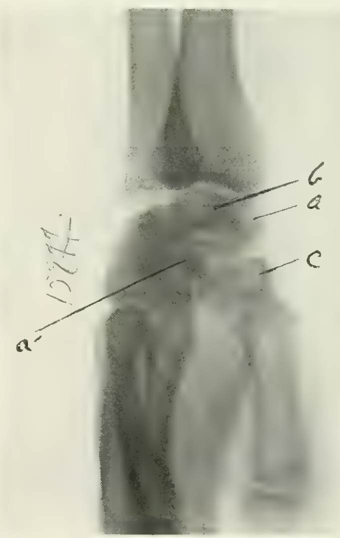
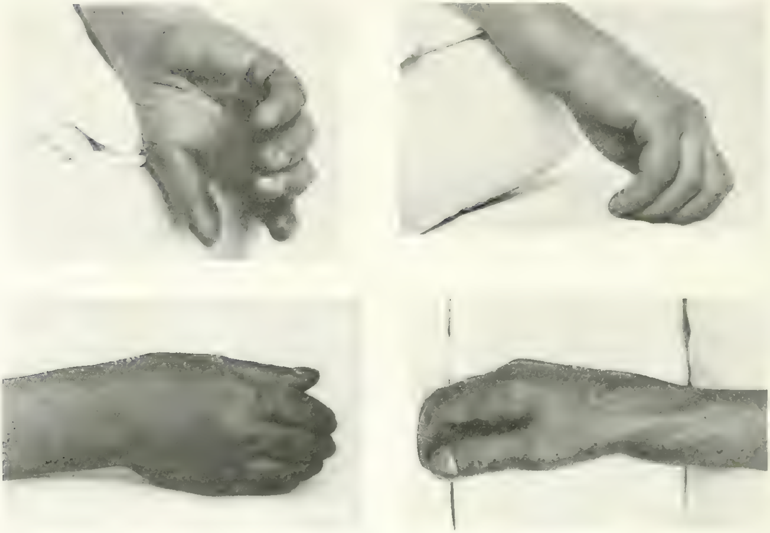


Fig. 610.—Same case from the side: (*a*) Distal fragment of scaphoid; (*a'*) distal fragment; (*b*) semilunar. This case was treated by excision of half the scaphoid (proximal half), of the semilunar, of the head of the magnum, and about half of the cuneiform. He recovered with a wrist fully useful for work, and not painful, though with some loss of motion.



Figs. 611–614.—Another case with the same lesions as the last—fracture of the scaphoid with dislocation of one carpal row backward on the other. The photographs in various views show the astonishingly small deformity produced by this serious lesion, and suggest an explanation of the fact that it is usually overlooked or treated as Colles' fracture (as this case was at first). The photographs were taken when he came to me nearly a year after the injury. The wrist was painful and almost without motion.

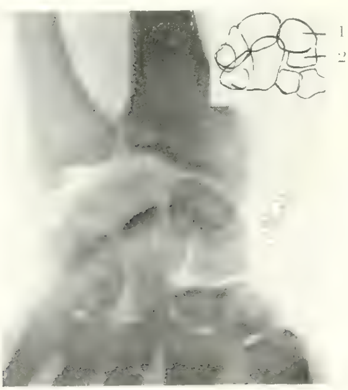


Fig. 615.—x-Ray of case shown in preceding photographs. The small drawing is an explanation of the confusing skiagraph. 1 and 2 are the fragments of the scaphoid; note the overlapping of one row of bones over the other.

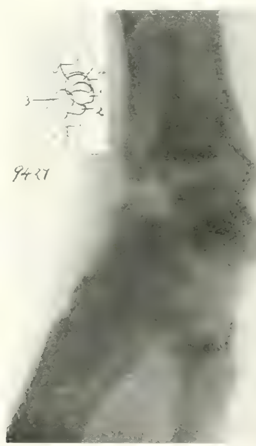


Fig. 616.—Same case, seen from the side: 1, Proximal fragment of scaphoid; 2, distal fragment of scaphoid; 3, os magnum; 4, semilunar. This wrist was operated on precisely as in the case shown in Figs. 609 and 610. Result, perfect use and strength. Slight limitation of extension.

All the cases seen at a later stage had been overlooked or misinterpreted at the time of the injury, though most of them had been seen by competent surgeons.

Fig. 617.—Same lesions as in last two cases (including in this case a fracture of the ulnar styloid). This cut shows well the difficulty of diagnosis. From this plate *alone* I doubt if any one would make the diagnosis of more than fracture of the scaphoid and of the ulnar styloid. The next plate, giving the *side view*, makes the matter clear.

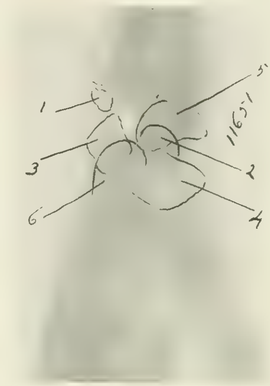


Fig. 618.—Lateral x-ray of same case: 1, Ulnar styloid; 2, proximal fragment of scaphoid; 3, cuneiform; 4, distal scaphoid fragment; 5, semilunar; 6, os magnum.

The difficulty here is obviously one of diagnosis. The deformity to sight or touch is far less than would be expected.

What may be seen is obvious from the illustrations here given.

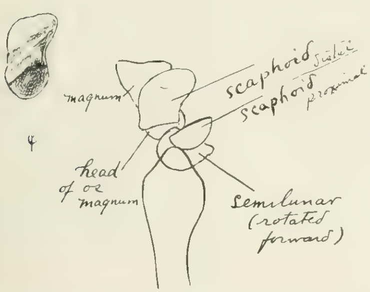


Fig. 619.—Same case (diagram). Upper left hand, drawing of normal scaphoid. The outline gives the displacements, but (drawn from the operation, not from the x-ray) gives the relations reversed, right and left.

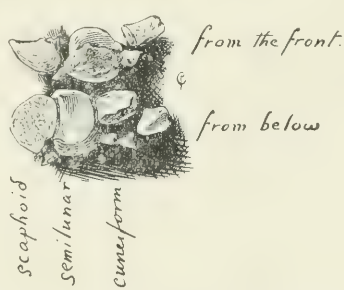


Fig. 620.—Fragments removed in above case (*cf.* Figs. 617, 618, 619) in excision. In this case the head of the os magnum was not removed. A good joint resulted, useful, with fair motion.

What may be felt is a projection on the back of the hand, not very obvious, and a thickening of the wrist.

There are loss of extension and of abduction and tenderness to touch, but, with all our aids, diagnosis is not always easy.

Given the diagnosis, there should be no difficulty in reduction of a fresh case by traction with alternate flexion and extension, combined with direct pressure on the projecting row of bones, as in the case cited. (See Fig. 621.) The restoration of motion to normal range, especially in extension, is the test of reduction and is conclusive.

Even where there is some doubt of detailed diagnosis—and I believe no man can be quite sure of these cases by manipulation alone—the reduction should be carried out in this way to be confirmed by the x-ray.*

The manœuvers given are efficient for all the various luxations in this region; the coexistence of carpal fracture is no contraindication to such reduction. As a rule, there is associated scaphoid fracture.

Where weeks have elapsed since the injury we may make the diagnosis without the x-ray or with it, but any question of simple reduction is foolish. Injuries in this region show a very prompt formation of scar tissue.

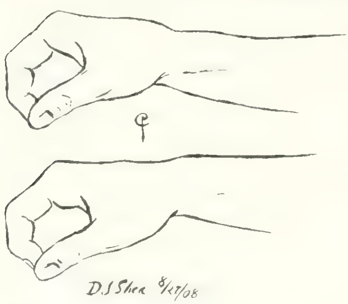


Fig. 621.—Diagram of position (in a case in which the x-ray showed the same lesion as in the preceding three cases) before and after reduction. This was a *fresh* case. Reduction complete; recovery perfect.

In these late cases we must intervene, but only with open incision.

In my cases of the sort I have done excision (of the proximal row of the carpus, at least, including the proximal fragment of the scaphoid), and have uniformly attained (in four cases) the tardy but very satisfactory result to be expected in radical wrist excisions—a practically perfect hand for work.

As to prognosis without operation, I can only say that I have seen no case that justified any expectation of a useful hand without surgical interference. In one case operated, for example, there were almost total loss of wrist motion and great pain on flexion of the fingers, apparently from the slipping past of one bone row on the other. The hand was useless for any work, though this patient was a gigantic Swede of huge muscles and no nervous system.†

Luxations of Single Bones

These may involve any bone and may be forward or back. Commonest is luxation of the semilunar forward‡ to a point where it forms

* A glance at the illustrations will show how easy it may be, even with the x-ray, to overlook this lesion unless we have x-rays also in *lateral* view.

† This case was operated on by excision. To-day he has an unbearably powerful grip, free wrist motion, and a perfectly useful hand, though hyperextension is less than normal.

‡ Such semilunar luxation may be complicated with a split of the scaphoid (see Fig. 624), and also the skiagraph of Bolton's early case (which I should interpret in this way) published in Ann. Surg., 1901, xxxiv, p. 291.

an obvious protuberance and gravely interferes with the action of the flexor tendons.

Where the luxation is complete—where both ends of the bone have left their normal relation—there is little left to do save excision, though I see no reason against all possible *attempts* to reduce. *Necrosis* of a dislocated bone in carpus (or tarsus) seems, in fact, to be a rare result, much as it might be expected theoretically.

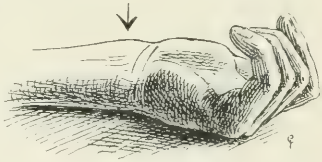


Fig. 622.—Isolated luxation of semilunar (and a chip of the scaphoid, proximal end) forward. Sketch made before operation. Arrow shows the lump (courtesy of Dr. H. A. Lothrop).

Dislocations of nearly every carpal bone singly are on record.

The diagnosis is essentially that of displacement of *some* bone out of its place. Which bone it is, is a matter of rough inference only.

Reduction can be attempted by traction on the hand with various rocking motions and pressure on the fragment we wish to push in place. The chance is small. I have not had, or seen, or heard of, any successful case, but it is worth trying.

Partial luxation of single bones of the carpus is not very rare. In these subluxations the os magnum is apt to be the bone involved. Sometimes it is the semilunar, or others. The following cases may be cited from my records. The reason for such citation is that these lesions seem little understood.

Fig. 623.—Backward dislocation of the semilunar bone, of unknown origin (perhaps congenital) in a boy. Disability mainly from loss of extension. Semilunar excised by Dr. Burrell, with good result (courtesy of Dr. H. L. Burrell).

Case.—B., aged twenty-four. Large athletic young man, woke up one morning unable to extend his right wrist. Other motions normal and painless. In the afternoon he was seen and examined and showed no swelling, no tenderness, but absolute bony locking that prevented extension of the wrist much beyond the straight line. Examination with the fluoroscope showed definite change of relation of the os magnum, with backward displacement of its proximal end. With this information I proceeded to reduce by traction, direct pressure, and extension of the wrist. The bone slipped back only after much force had been used, but motions all became normal and painless, and the patient resumed use of the hand without any trouble ensuing. This case seems to have been a displacement due to some muscular action during sleep, probably acting through overflexion.

Case.—D., girl of twenty. As a result of an accident nearly a year ago has been unable to extend the wrist fully or to abduct it without pain. Since two weeks after the injury there is said to have been

nothing abnormal to be *seen* about the wrist. Flexion and abduction normal. Skiagraph shows no fracture, but apparent partial displacement of the os magnum forward. Treatment refused. Case lost sight of.

Case.—C., woman of twenty-seven years of age. Athletic young woman; injured the wrist by shoving against a swimming raft. Had disability for a few days; since then has had occasional periods of disability, lasting a few days only, during which she was unable to extend

Fig. 624.—Bones removed by operation in Dr. Lothrop's case. Semilunar and fragment of scaphoid seen from below. Drawn (by courtesy of Dr. Lothrop) from his specimen.

Fig. 625.—Dislocation of semilunar forward (also some damage to radius). Drawn from the plaster cast (Warren Museum, specimen 9566).

the hand and had some pain. During one of these periods she presented herself to me. Objectively, there was nothing excepting limitation, somewhat painful, of extension and abduction of the hand, apparently centered at the os magnum. A skiagraph was taken to exclude possible fractured scaphoid. The day this was taken the limitation of motion *suddenly* disappeared, as it had on previous occasions, as suddenly as it came, and the wrist when next seen was entirely normal except for some general laxity of ligaments. Support and exercises advised and carried out; no recurrence in two years. This case seems to have been of the same type as the two preceding.

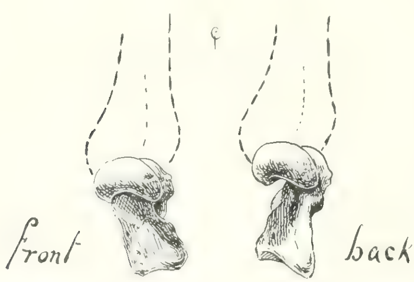


Fig. 626. Range of motion between semilunar and magnum in flexion and extension.

Case.—G., woman of forty. Fell and had, as a consequence of trying to save herself, a partial backward dislocation of the proximal end of the magnum. Reduced by traction and pressure and rocking from side to side. Perfect restoration of function.

Case.—X., seen with Dr. J. B. Blake. Young professional pugilist. In a recent fight he hurt his wrist, and on resumption of training he found there was something wrong, about which he sought advice. Wrist on inspection seemed entirely normal, but when he clenched his hand there was a motion, easily felt, of the semilunar bone of the right hand forward. The range of motion was not over $\frac{1}{6}$ to $\frac{1}{4}$ inch, but occurred each time that the fist was clenched, and was accompanied

with a soft click. There was considerable professional disability. For ordinary use the wrist was normal.

Case.—Girl of about twenty. In the course of scrubbing she slipped and in some way hurt her hand by striking it against the floor. Comes in on account of pain. Examination shows tenderness about the right pisiform bone and very marked mobility of this bone with a click upon motion. The bone of the opposite side more movable than usual, but distinctly less so than on the injured right side. Any motion calling the ulnar flexor into action is painful. Curiously enough, this injury, which was diagnosed as a partial luxation of the pisiform, was accompanied by pain and some anesthetic disturbance in the ulnar nerve, evidently pressed on by the bone at the time of its first displacement. Several weeks of fixation failed to improve the symptoms in this case very much. She was then lost sight of.

Fig. 627.—Subluxation of os magnum *forward*. Result of trauma, reduced by manipulation.

One case of upward luxation of the trapezium has come to my notice (see Fig. 629), but this was merely a complication of dislocation between proximal and distal rows of the carpus.

These cases illustrate, what is not very infrequent, a *partial* displacement of one or another carpal bone, which may or may not be permanent or become habitual. It will readily be seen that, as these bones receive practically no muscular insertions, any displacement, however slight,

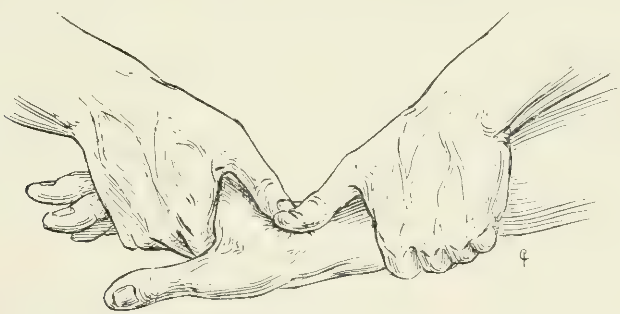


Fig. 628. -Form of reduction successfully applied in two cases in which the x-ray showed a luxation or a subluxation backward of the os magnum on the semilunar.

that involved a folding-in of the capsule, might not tend to spontaneous reduction, and any such displacement accompanied by loosening or tearing of ligaments would tend to recur. The matter of diagnosis comes down to a question of exclusion of fracture or general ligamentous strain, and a localization of the trouble at one or the other point in the carpus. Except in case of backward dislocation of the magnum or

forward dislocation of the semilunar, which may be helped by traction

Fig. 629.—Luxation of trapezium from scaphoid, up and outward. Partial luxation of one carpal row on the other, also. Considerable deformity. Not reduced because of other more serious injuries and poor condition of patient.

and direct pressure, the writer is at a loss in regard to special manipulations.

Fracture with Carpal Dislocations

Such injuries as give fractures of the carpus by direct violence are apt also to give separation of fragments or total disruption of the carpus. These injuries are sometimes compound, and if so, are to be treated by excision of the broken or isolated bones.

There is only one form of fracture which seems particularly likely to be associated with dislocation, viz., the fracture of the scaphoid, which, in part, belongs to the distal and in part to the proximal row. In five cases that the writer has met with, and in two others of which he has personal knowledge, this combination was found.

Symptoms and Treatment.—It would seem that an injury of such gravity and extent should be easy to diagnose. As a matter of fact, all the dislocations in the carpus, as with the tarsus, seem curiously deceptive, and, as will be seen from the case histories above appended, the only significant symptoms seem to be a little thickening of the wrist, some lameness and loss of motion, particularly in extension. Even the x-ray is not necessarily conclusive, and the appearances in the front view—the one usually relied on—are so nearly natural that any one save an expert would probably pass them as normal unless for the scaphoid fracture.

The moral is that we should always take *two* views in doubtful wrist injuries.

No doubt if the diagnosis were made, reduction of the dislocation and replacement of the scaphoid fracture would be easy, though apparently it has not been done, save in the author's case, above noted. In one other of the cases noted there was little difficulty in reducing the bones after cutting down on them, though it seemed unwise to trust the permanency of this reduction. The manipulation for reduction is, as in dislocation of the os magnum alone, flexion to clear the way, then traction with pressure on the fragment and extension of the joint. In the late cases there is nothing to do but let them alone, or to operate as was done in the author's cases.

Fig. 630.—Point of tenderness on pressure, and, in cases with displacement of thickening, in scaphoid fracture.

FRACTURES OF THE CARPUS

Until recently the statement has been accepted pretty generally that fractures of the carpus are almost always results of direct crushing violence. The possibility of fractures of the scaphoid in particular, produced by falls on the hand, was recognized nearly a century ago, but it is only recently, particularly since the study of *x*-rays, that we have come to realize that these fractures are not rare, relatively speaking; that they may cause considerable disability, and that this disability is entirely remediable under proper handling. In discussing these fractures it will be well to speak first of—

Fractures of the Carpal Scaphoid

These occur from falls on the hand or from like forms of violence of the sort that more usually give a Colles fracture.* The lesion is a break across the scaphoid at its "neck" (see Fig. 631), where it is comparatively narrow, and where it is subject to a critical cross-strain in any fall where there is *pronation* of the hand. Apparently, there is no considerable displacement in the

* Wolff, of Sonnenburg's clinic, in an admirable article (Monatsschrift f. Unfallheilkunde, 1905, xii, S. 363–394), credits Immelmann with the demonstration of the possibility (which he accepts) of scaphoid fracture from simple forced *supination*. He gives two cases where this seemed to be the mechanism. He also gives cases of his own, and cites others of Blau's, of alleged *impacted* scaphoid fracture, but his data as to these cases seem hardly convincing.

majority of these cases immediately following the accident. The clinical picture is one of a "sprained wrist," showing tenderness to all motions, but particularly to extension and radial flexion, and a tenderness to pressure more or less localized over the scaphoid, front and back—tenderness especially marked in the "anatomic snuff-box" when the hand is in (ulnar) adduction. At this time no more than an inferential diagnosis may usually be made, and a considerable number of "sprains" presenting these symptoms in mild degree, at least, may well

Fig. 631.—Right wrist from the side. Note how the obliquity of the scaphoid down and forward and the relatively thin "neck" expose it to fracture in falls.

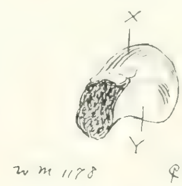


Fig. 632.—Proximal fragment of broken scaphoid. *X* is the articular surface for the radius. *Y* is that for the head of the os magnum (Warren Museum, specimen 1178).

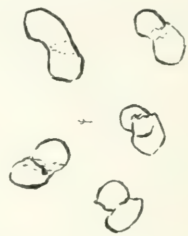


Fig. 633. — Sketches of broken scaphoid from various *x*-rays (seen from the front). These sketches illustrate the *varying amount of displacement.*

be fractures of the scaphoid. In these fresh cases the *x*-ray is often essential to diagnosis.* In the later cases, however, the picture becomes more typical if the trouble is serious, that is, if there is dis-

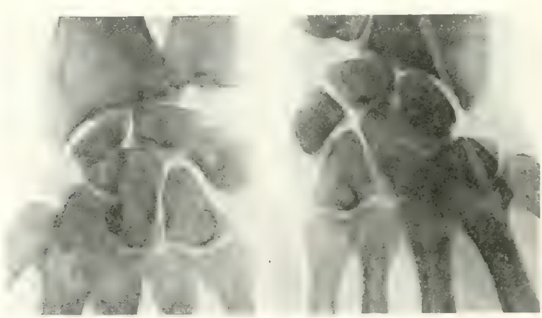


Fig. 634.—*x*-Rays of a case of double scaphoid fracture.

placement of fragments, whether this displacement is primary or, as seems usual, only a displacement following on attempted use. With

* Roughly, one-third to one-half of the fresh cases of injury in which I have found enough of these signs to be suspicious have shown no fracture in the *x*-ray, and have recovered promptly.

such displacement there is a thickening of the wrist antero-posteriorly opposite the scaphoid, some tenderness, and a limitation of

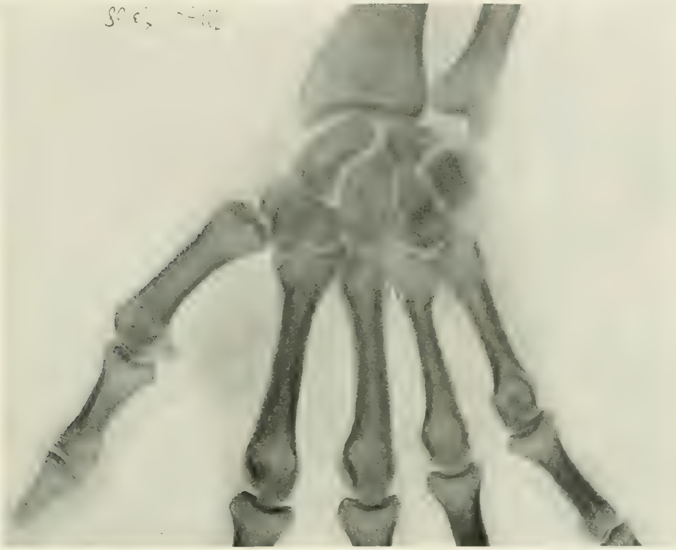


Fig. 635.—A cracked scaphoid without displacement. Result of fall on the hand. Long-continued tenderness over scaphoid and impaired usefulness. *x*-Ray (taken three weeks after injury) shows the line of break with a slight gap. (*x*-Ray plate by Dr. Arial W. George.)

motion in the direction of radial extension and radial abduction, while ulnar flexion, ulnar extension, and straight flexion are entirely unimpeded.

Fig. 636.—Fracture of scaphoid on the left; line of fracture unusually high; displacement almost none. Right side shows normal carpus.

This combination of symptoms, persisting long after an injury, definitely means some damage to the carpus; usually it means scaphoid fracture.*

* Dr. T. Dwight, the anatomist, has dwelt much (most lately in his "Variations

The limitation of motion is due to a displacement of the fragment, as shown in the sketch (Fig. 633), rarely to the interference of a third fragment.

There are certain other cases of undoubted fracture of the scaphoid where the function becomes practically normal, and where there is never any dislocation, never any definite thickening, and no consequences unless, as the writer has once seen, there has been a fresh strain from a second fall, which gives more prolonged lameness than would happen with normal bones, with tenderness localized about the scaphoid. So far as we know, these scaphoid fractures never unite save by fibrous tissue, but such union may be very serviceable.

If such serviceable union is present or promised, we have no call to interfere.

In other cases, however, there is displacement (primary or late), loss of motion, and much lameness.

Fig. 637.—Fracture of scaphoid several months after injury. Some deformity, severe disability. Not operated on because of alcoholism—usually an operable type of case.

Fig. 638.—Fracture of scaphoid (lateral view). Little displacement Disability was only moderate.

Displacement is not strictly constant in range or direction; motion in abduction and extension are usually most interfered with.

Treatment is by partial excision.

The good results obtainable are dependent on successful removal of one or two mutually impeding and irritating fragments.

The one usually removed is the proximal, because it is easiest to get. Once I removed a *third* fragment in between, as well as the proximal part.

There is no trouble from the loss of the bone. In the writer's cases (only three in all) in which such excisions have been done for fractured scaphoid *uncomplicated*, the results have been practically perfect, save

of the Bones of the Hand and Foot," Lippincott, 1907) on the probability of error between separate ossification centers and fracture.

Obviously, there is something in this, but in cases showing clinical signs of fresh damage, and in those furnishing specimens and skiagraphs like those of Figs. 624 and 632, there can be no question that the lesion is traumatic.

in one case (immobilized too long in the out-patient department), in which there was some finger stiffness.

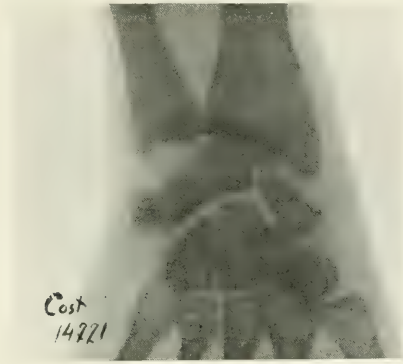


Fig. 639.—Fracture of scaphoid with displacement.

Fig. 640.—Fracture of scaphoid with displacement. Grave disability. Operation (late) with removal of proximal fragment. Recovery with perfect motion and function.

Fig. 641.—Scaphoid fracture with displacement in a man of fifty. Removal of projecting *distal* fragment. Fair result. (In this case there was *sub*luxation of row on row, which was not treated.)

Fracture of Scaphoid with Total Semilunar Luxation *

The writer has seen but one case (Fig. 624), seen in the service of Dr. H. A. Lothrop. The semilunar bone was luxated forward. It was excised, and only at the operation was it recognized that the proximal part of the scaphoid had followed the semilunar in its forward displacement. The result of the operation was excellent.

Fracture of Other Carpal Bones

No bone of the carpus is exempt from the chance of fracture, but, save for those noted, there are no *types* of fracture.

* See also under Luxation of the One Row on the Other as to the type of *rotary* luxation of the semilunar with broken scaphoid—an entirely different matter.

Diagnosis of the atypical fractures is hardly practicable, save with the aid of the skiagraph.

We have no rules for treatment as yet.

ANATOMY OF THE EPIPHYSES OF THE HAND

In injuries of the metacarpus and carpus the epiphyses play little part. Fig. 642 shows where they lie. Rarely, they may be displaced.

Fig. 642. x Ray of normal hand.

More often, a knowledge of the normal epiphyses, like acquaintance with the sesamoids, is of service in avoiding the diagnosis of fracture where none is present.

CHAPTER XVIII

METACARPAL INJURIES

LUXATIONS OF THE METACARPALS

Luxations of the metacarpals are very rare except in case of the first. The luxation backward of the thumb metacarpal is a special accident caused by special violence. Corresponding dislocation of the other four is not produced in the same way, although similar violence sometimes leads to partial luxation. Where the metacarpals of the fingers

Fig. 643.—Mechanism of luxation of the base of the first metacarpal outward. How to hit the "Sullivan blow." The wrist is turned so that the *knuckles* meet a resistance coming in the line of the arrow.

Fig. 644.—The way a "drunk" carries it out. The turning of the hand is incomplete or too long delayed, and the resistance is met by the *distal* end of the first metacarpal.

are displaced backward, there is often a fracture of the base of the bone, owing to the direction in which the force is necessarily received.

Dislocation of the Thumb Metacarpal Backward

This is the common lesion, or the least uncommon. It appears as a dislocation backward by simple tearing of the posterior capsule of the joint. Owing to the comparatively flat surface of this joint, there is nothing except this capsule to hold the bone in place, and the dislocation is very apt to be one that reduces itself and reproduces itself according as the thumb is extended or flexed, according to the mechanism presently to be explained. All these cases seen by the writer, now numbering certainly over a dozen, have been due to one cause—namely, the striking of a blow in such fashion as to "land" with the thumb knuckle on the other man's head. This is a technical error in the delivery of the so-called "round-arm blow," an error by which the wrist is not

pronated and extended quickly enough, so that the knuckle shall be in front when the blow lands. It is, accordingly, an accident rarely occurring to the skilled boxer, and unlikely to occur to any man whose nerve processes have not been somewhat slowed up by drinking. This is why this injury is so constantly the result of a drunken fracas.

Fig. 645. — The force acts on the "thumb-knuckle" (upper arrow) and drives it inward. The mass of contracted muscle x, held firm by the clenched fingers, acts as a fulcrum, and the *base* of the metacarpal is pried outward (lower arrow).

The mechanism of production seems to be a tearing across of the capsule by a lifting outward and backward of the metacarpal base. The blow is struck on the opposite end of the metacarpal, and an efficient fulcrum for the lift is furnished by the flexed fingers and the contracted muscles of the thumb, which form a hard mass in the clenched fist. (See Fig. 645.)

The accident involves relatively little tissue damage, and is not immediately painful to any great extent. The hand can be used, but on the following day the man notices that the thumb is weak, or that there is a slipping at this joint. When the fist is clenched, the action of the flexor tendons acts to reproduce the same leverage over the same fulcrum as before, and the base of the bone is slipped out. There is no difficulty whatever about putting it back accurately in position. There is, however, a great deal of difficulty in keeping it there.

Treatment.—Extension of the thumb and direct pressure over the metacarpal base are to be secured. This may best be done by a tin splint with a ridged back, as shown in the cut (Fig. 646). With the hand firmly strapped to this splint, a pretty accurate retention of position is possible. In this position contraction of the flexor muscles has little tendency to reproduce the dislocation. Fixation must be continued for a considerable time, certainly over three weeks, for the repair of this joint calls for a very strong new capsule, as this newly formed capsule is to be the only support of the joint.*

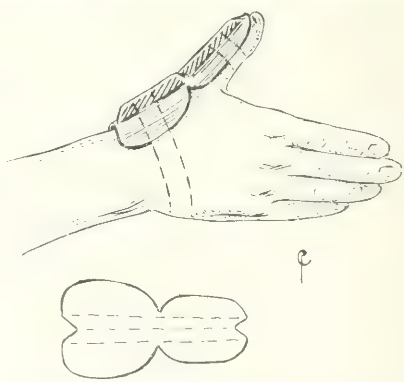


Fig. 646.—"Gutter splint" of tin. Lower cut shows the pattern. For details of making compare Fig. 314.

* I know of no cases of operation for this condition, but have in the past seen cases of results so poor that operation for fixation would be, under modern conditions, the desirable course.

Results.—With adequate protection and fixation there seems no reason why good results should not be secured. As a matter of fact, however, the writer has not been able in any case treated to secure really satisfactory results, mainly because the patients insisted on early use of the hand. There has been always some weakness, and in several cases slight slipping of the joint upon vigorous use of the hand, which did not disappear with time. We have here the same condition, so far as the condition of the joint is concerned, that obtains in acromioclavicular dislocation, in which, also, the resulting repair is often insufficient to withstand heavy work. In the thumb injury, moreover, we have to deal usually with the sort of man who is not likely to pay very much attention to after-treatment.

As to the results of this injury where there has been no attempt at treatment, the writer has seen but one case. Here the injury, received many years before, had apparently been a pure dislocation and had resulted in very considerable deformity, with some loss of extension due to the position of the bone, but with the thumb functionally about as good as has resulted in any of the cases treated.

Other Luxations of the Metacarpal Bases

Luxation of any one of the metacarpal bones may occur as a result of direct or indirect violence.* Such luxations are reduced by traction

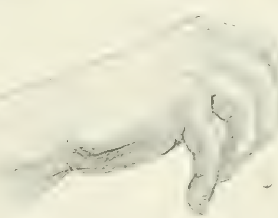


Fig. 647.—Luxation of fifth metacarpal inward and backward. Result of striking a blow. Readily reduced by traction and pressure (sketched from a case of the writer's).

on the finger corresponding and direct pressure applied to shove the bone back into place. There is no especial condition making for redisplacement, as in the last variety of injury, and the results are good, as they are with most other dislocations of the bones of the hand. Treatment after reduction consists of the application of a straight rest splint and gradual resumption of use after two or three weeks.

Dislocations of the Knuckles (Phalangeo-Metacarpal)

Here again we must distinguish between the thumb and the fingers. For here again there is a special mechanism governing, in this case, not the dislocation, but the replacement after dislocation.

* The injury shown in Fig. 647 was the result of striking with this hand; the bone held, but was driven out of its joint at the base.

Dislocation of the Thumb at the Metacarpophalangeal Joint

This is one of the classic injuries, not, however, a common injury, and not always showing its classic features. The type dislocation is of the phalanx backward on the metacarpal, a dislocation produced by

Fig. 648.—Dislocation of the thumb backward. "First degree" (diagram).

Fig. 649.—Thumb luxation, "second degree." The thumb has been straightened without reduction. Phalanx and metacarpal lie nearly parallel, but overlapping.

hyperextension of the thumb. There is a tearing of the anterior part of the capsule and a displacement of the phalanx upward and backward behind the rounded head of the metacarpal. The displacement is divided, according to the classic writers, into two types, a first and a second degree. The first degree is that in which the phalanx remains hyperextended (Fig. 648); the second, that in which efforts of reduction have brought the phalanx down parallel to the metacarpal bone, without reducing the dislocation (Fig. 649). The obstacle to reduction, particularly in the second type, is an interposition of the torn portion of the anterior capsule between the two bones. Every text-book also outlines the way in which the head of the metacarpal is caught between the tendon of the long flexor tendon and one head of the flexor brevis (Fig. 650). There is no doubt that this has occurred, but the writer is inclined to be skeptical about it as a routine feature of this dislocation, and is inclined to think the difficulty of reduction somewhat overestimated. The presence of the torn capsule is, however, commonly present, and is the reason for the special form of reduction generally agreed upon.

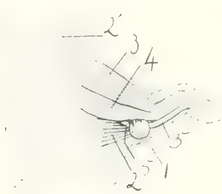


Fig. 650.—The metacarpal head may become "buttonholed" between tendons: 1, Metacarpal head; 2, short flexor, inner head; 3, abductor pollicis; 4, short flexor, outer head; 2′, 5, and 5, tendon of *long* flexor.

Reduction. The manipulations are as follows: Hyperextension of the thumb, whether it be found in the so-called first or in the second

position; hyperextension sufficient to relieve pressure on the front edge of the end of the phalanx. With the thumb still hyperextended the thumb is *shoved*, not pulled, down toward its normal position at the metacarpal head. With this motion is combined a rocking and rotating motion, tending to help in keeping the capsule ahead of the bone. The phalanx slips in place suddenly, and shows no definite tendency to become displaced again. The writer has seen no cases in which this manœuver, a few times repeated, did not succeed. In case it does not succeed, however, the probability would be in favor of the supposition that the metacarpal head was really buttonholed between the flexor tendons If this is the case, there is no recourse but open opera-

Fig. 651.—Extend thumb (reducing second to first degree); then carry thumb down the metacarpal, base first, so to speak, until it slips over the metacarpal head.

tion, and the reduction by means of enlargement of the buttonhole so formed and by direct manipulation under the eye.

The after-treatment of this dislocation is not different from that of most, and the only comment to be made is that a good deal of joint thickening results, with a limitation of motion persisting for a long time—sometimes permanent, so far as hyperextension is concerned.

Other Dislocations of this Joint

These belong to the rarities, and are apt to be only subluxations, most often lateral, due to ruptures of ligament, and requiring no especial form of reduction or treatment.

The writer has, however, seen two cases of luxation forward. (See Fig. 652.) Both were cases of many weeks' duration. In both the disability was great, consisting of inability to extend the joints, and in one case of loss of strength, entirely preventing work: this man was a bench machinist.

Both cases were reduced by open incision, with a good result in the latter, a perfect result in the former case.*

Fig. 652.—Dislocation of thumb phalanx inward and forward under the metacarpal head. Old lesion in this case, successfully reduced by open operation.

METACARPAL FRACTURE

Fracture of the First Metacarpal

Fractures of the *thumb* metacarpal at the distal end or through the shaft are uncommon. They are apt to be the result of *direct* trauma.

Fig. 653.—Fracture of first metacarpal, distal end.

The bone is so isolated that diagnosis is rarely difficult. If there is doubt, measurement of shortening, carried out not with the tape, but as shown in Fig. 655, is of service.

Fractures of the metacarpal bone of the thumb cannot well be treated on the straight splint.

* This case was one of tabes, in which ataxic muscle action had aggravated the result of the original trauma, and interfered greatly with repair after reduction.

Either the gutter splint made of tin or the Goldthwait splint are more serviceable. These must be made for each case, and the method of making and fitting them is shown in the accompanying sketches (Figs. 646 and 654).

Fracture of the Base of the Metacarpal of the Thumb

Two forms of fracture of this special metacarpal are to be considered separately. The first is a true impacted fracture of the shaft of the first metacarpal into its own base. It is produced by a force acting in the line of the long axis of the bone. The diagnosis rests on shortening of the thumb, on thickening about its base, on localized tenderness. This shortening is most important.* There is nothing to be done, or nothing that should be done, to reduce this fracture. It is impacted,

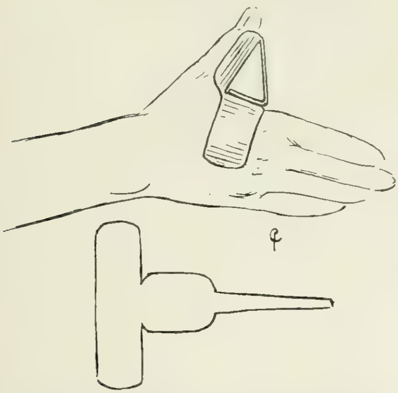


Fig. 654.—Goldthwait's thumb splint. The lower sketch shows the pattern to be cut out of light tin; the folding and bending necessary will be understood from the upper sketch.

Fig. 655.—Relation of tips of thumb to first interphalangeal skin-fold of first finger. Much better measure of any shortening of the thumb than we can get with a tape.

and should be allowed to remain impacted. Function is restored very satisfactorily after reasonable rest and fixation, and the deformity is limited to thickening and to a shortening which, while distinct, is not conspicuous or important.

The other form of fracture to be considered is the fracture produced by similar violence, which runs upward and backward through the base of the bone.† This displacement is upward and backward, and the

* Shortening of the thumb may best be measured by determining the relation of the end of the adducted thumb to the finger knuckle of the forefinger (Fig. 655). In the uninjured hand the tip of the thumb comes just about to the middle wrinkle overlying this joint.

† This is Bennett's "stave of the thumb." Bennett, Brit. Med. Jour., 1885, ii, 200; *Ibid.*, 1886, ii, p. 13; Dublin Jour. Med. Sci., 1882, lxxiii, p. 72. Russ, Jour. Amer. Med. Assoc., June 16, 1906, p. 1824; and Robinson, Boston Med. and Surg. Jour., 1908, p. 275—have published more recent series of such cases.

fracture is not uniformly impacted. In appearance it almost exactly resembles the dislocation of the joint, but is either not so freely movable as is the dislocation or, if movable, is movable with crepitus.

It is to be treated by obtaining the best possible position and applying either the gutter splint, with fixation by traction straps, with or without rubber strips, or the Goldthwait splint, with a firm pad over the head of the bone.

Some thickening and some backward prominence remain after consolidation, but function is not interfered with. Functional results are far better than with the luxation.

Fig. 656.—Old impacted fracture of first metacarpal near base.

Fig. 657.—Bennett's fracture, the "stave of the thumb," a splitting off of part of the base of the bone, with displacement of the *shaft* up and back (author's case).

Fractures of the other Metacarpal Bones

The metacarpal bones may be fractured at any point in their length. Fractures of the *shaft* are, however, almost entirely confined to the result of direct violence, while fractures of the bases and heads of the bones are often produced by blows received on the knuckles acting more or less accurately in the direction of the long axis of the bones. The commonest fracture is that of the head of the metacarpal just behind the knuckle.

Knuckle Fracture

This fracture does not ordinarily involve the articular surface of the bone, but consists of a break, usually oblique, most often oblique

Fig. 658.—Test for tenderness, mobility, and crepitus by pressure in the axis of the suspected metacarpal.

upward and forward, close behind the expanded head of the bone. There is, as a rule, more or less entanglement of the fractured surfaces; that is, apparent impaction; real impaction is not the rule.

Symptoms.—There is swelling of the hand, pain, and some disability. The diagnostic symptoms are as follows: Shortening of the bone. Dropping of the knuckle. Pain on pressure in the long axis of the bone. Limitation of active flexion. Crepitus.

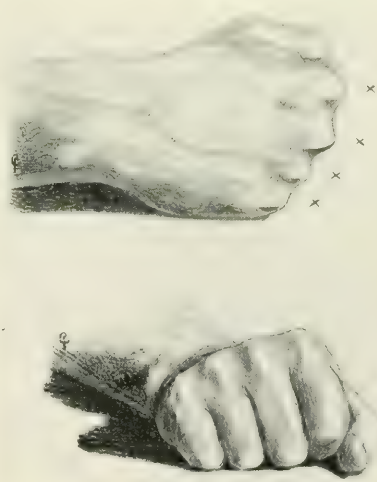


Fig. 659.—The normal fist, clenched. The stars show the normal relations of knuckles seen from behind; the last three are in a straight line. Seen "end on," the knuckles and "finger knuckles" show nearly straight lines; the finger knuckles, save that of the forefinger, lie flat on the table.

If there is any considerable swelling, these points are not easy to make out. *Shortening* of the bone is made out not by measurement, but by inspection of the knuckles with the fist closed. The last three knuckles are in this position in a straight line in nearly all hands. The relation of the first knuckle to the others is pretty constant, and should be the same in both hands. If this inspection is carried out in this way, there is really no difficulty in ascertaining the shortening. (Compare Figs. 659 and 661.)

The *dropping* of the knuckle is to be sought for in another view of

the clenched hand, as shown in the lower sketch in Fig. 659. If present, it is usually obvious when looked for in this view. If there is any question, it may be settled by the line of the *finger knuckle*, which necessarily is also altered if the dropping is present (Fig. 659).

Fig. 660. The arrow shows an *extra* epiphysis (not very rare) at the base of the second metacarpal. Ordinarily, the *single* epiphysis is at the *proximal* end of the first metacarpal, at the *distal* end n the other four. This plate shows also a crack (x to x) of the third metacarpal.

Pain on pressure in the axis of the bone is constant, and needs no explanation. It is not necessarily very severe. (See Fig. 658.)

Limitation in flexion is apparently due partly to tenderness, partly to disturbance of the relations of the flexor tendon.

Crepitus is not present, as a rule.

The greatest diagnostic difficulty presented by these fractures presents itself in case the patient is known to have had some *previous* fracture of some knuckle. Often we can no longer depend upon deformity, but must rely upon pain and crepitus and upon mobility. The last two signs are usually demonstrated only with the use of a good deal of force.

The majority of knuckle fractures are received in striking blows with the hand, and are the pugilist's fracture *par excellence*. The knuckles most commonly fractured are those of the fourth and fifth metacarpals.

Treatment.—The deformity is to be reduced by strong traction on the corresponding finger and by direct pressure of the head backward. Sometimes a rocking motion added to the traction is of service. Reduction to a perfect position is often not attainable, and maintenance of the position first obtained is difficult.

Fig. 661. Broken metacarpal. The fourth metacarpal shows the knuckle pushed back out of the normally straight line from third to fifth (compare Fig. 659).

There are two methods of treating this sort of fracture. The first is by flexion of the hand around a roller, the second by treatment in the straight position, with or without traction. In treating the hand in flexion a roller, most conveniently a roll of bandage, should be used. This should be about an inch in thickness and about three or four inches in length, corresponding to the width of

the hand. It is placed in the palm of the hand, the fracture is pulled into place, and all the fingers flexed firmly about the bandage. In

Fig. 662.—Fracture of second metacarpal. Note how the knuckle end has dropped into the palm of the hand (outlines reinforced).

this position they are held by straps of adhesive plaster applied as shown in Fig. 665. This method is reasonably satisfactory as regards results. The only disadvantage is that it is often distinctly uncomfortable.

Treatment in the extended position consists in the application of a splint anteriorly, cut to fit the hand as shown

Fig. 663.—Fracture of fifth metacarpal; old, united.

Fig. 664.—Fracture of fifth metacarpal, distal end.

in Fig. 666. It should go out somewhat beyond the tips of the fingers, and well up the forearm. It is padded in the usual way, with the

addition of a pad, preferably of thick felt, in the palm of the hand. The wrist and forearm are firmly fastened with plaster to this splint, and the finger corresponding to the broken knuckle is held in place by strips of adhesive carried over the end of the splint. Care must be taken to see that this adhesive does not cut into the sides of the finger at the tip, and does not press upon the nail, or it will be unendurable to the patient. In certain cases it may be well to use a somewhat longer splint and to fasten this adhesive plaster to elastic strips, or, better still, to rubber tubing, which is carried over the end of the splint, stretched, and fastened (Fig. 667). Whatever method of treatment is adopted, it is necessary to change apparatus every day or every other day, until union has begun to be pretty firm, partly because the discomfort of any efficient traction becomes considerable if the straps be left in one position, partly because any apparatus applied to the hand tends to slip and to become inefficient.

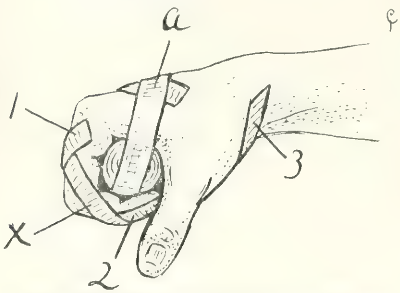


Fig. 665.—Bandage roll in palm. Fingers fastened in flexion and under traction; *a* holds the roll in place. Straps x and 1, 2, 3, hold the fingers in place. This dressing prevents projection of the bones into the palm. It is not very comfortable.

So far as the choice of apparatus is concerned, it may be said that the flexed and the extended positions are about equally effective, provided that in the extended position the pads be made large enough. The advantages of the elastic traction do not seem to be worth the additional

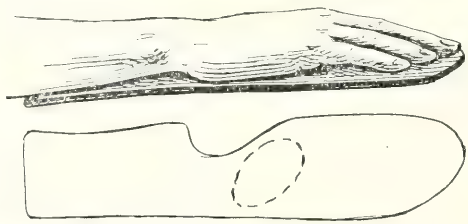


Fig. 666.—Straight palmar splint, cut out for the thumb. A pad to fill the palm is placed as shown by the dotted line.

discomfort involved, as a rule. Owing to the fact that muscle action greatly tends to reproduce the deformity, treatment in apparatus must be long continued—a month at least—to insure good results.

Results.—Some part of the deformity, both of shortening and of the "dropped knuckle," almost invariably remains. The function may be impaired to some extent by limitation of flexion, but is nearly always

good. In fact, it is often astonishingly good with poor position, as will be seen from inspection of the hand of any old prize-fighter. Many of these men have had a number of such fractures without loss of strength or of usefulness of the hand for their purpose. Dr. H. L. Burrell had a case in his practice* in which a man had had in the right

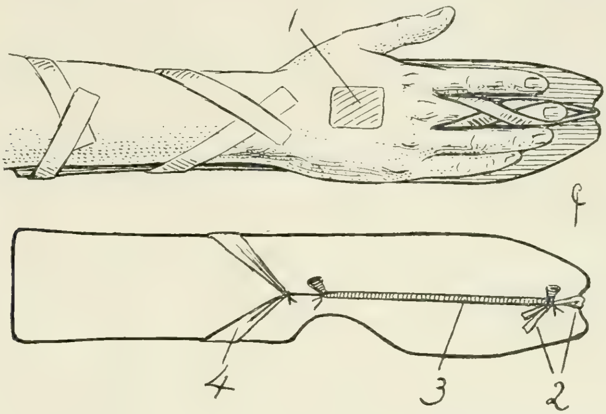


Fig. 667.—Elastic traction, applied for fracture of middle finger metacarpal. Splint of light board longer than the band: 1, Pad over fragments; 2, ends of adhesive that pulls on the fingers tied to a piece of rubber tubing (3), which is stretched and tied to adhesives (4) that fasten it to the splint. The wrist is held to the splint by adhesives. The rubber exerts a pull, transmitted over the smooth notched end of the splint to the extension adhesives on the finger (the lower sketch shows the *palmar* side of splint).

and left hands 16 such fractures without serious impairment of function save in one knuckle which had been carelessly treated and came to an open operation.

Fractures of the Shaft of the Metacarpal

These are usually the result of direct violence, and are apt to be approximately transverse, with the displacement in the direction of an anterior or posterior bowing. They show little or no shortening of the bone, but on careful inspection deformity, mobility, and crepitus are all present. Owing to the swelling of the hand from an injury, such as produces these fractures, they are very readily overlooked, and if overlooked, may produce serious trouble. This trouble is owing to deformity which gives a projection on either the front or back of the hand, serious so far as the backward displacement is concerned only because such projections are constantly getting struck; far more serious if the displacement is forward, because such displace-

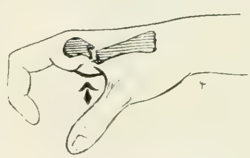


Fig. 668.—There is a strong tendency for the fragments, or one of them, to be displaced into the palm.

* Personal communication.

ment causes painful pressure in the palm of the hand when the hand is used to grasp anything.

They are to be treated on a straight anterior splint, with the pad in the palm of the hand. Because of the seriousness of a projection in the palm it is wise to err, if at all, in the direction of padding too heavily in the palm. These fractures unite readily, but must be protected for some time after union is apparently firm, because if the hand is used for work, the action of the flexor muscles tends to produce bowing of the bone. This protection, so far, at least, as abstinence from heavy work is concerned, should continue for six weeks after the injury.

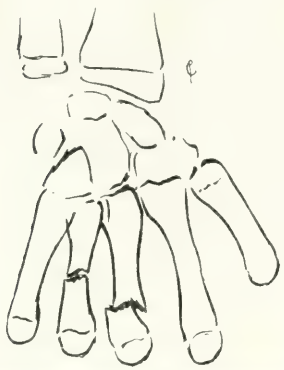


Fig. 669. Fracture of two metacarpals.

Fig. 670. Spiral fractures of two metacarpals.

Fractures of the Bases of the Metacarpals

These are produced, in the majority of instances, by indirect violence. They are commonly either fractures within a half inch of the joint surface, roughly transverse, or oblique fractures *involving* the joint surfaces. The detection of such fractures is often difficult, because the deformity is little or none, and mobility or crepitus can hardly be made out. Localized tenderness and thickening and pain on pressure in the long axis of the bone may make us suspect them, but the actual diagnosis must often be made by the x-ray. They are serious only because certain ones of them remain persistently tender after injury. The reason of this is, I think, unknown, nor is it dependent upon any defective treatment. Treatment can at most consist only of a reduction by traction and pressure if there is any deformity, and of subsequent rest in splints.

CHAPTER XIX

THE PHALANGES

DISLOCATIONS OF THE PHALANGES *

These dislocations are oftenest produced, in the case of the backward dislocation, by hyperextension; in the case of the forward dislocation, by direct violence.

Lateral luxations are not rare. They offer no special peculiarities as to diagnosis; deformity is obvious.

As to treatment, there is only to be said that the same difficulty with the capsule may be met with as in the thumb luxations, and must be treated similarly.

Fig. 671.—Anatomy of phalanges of thumb and index. The crosses show the sites of common though not constant sesamoids, that are often confusing.

Most of the luxations are reducible by simple traction and pressure, and are treated by simple immobilization, best continued only for a few days, and followed by active and passive motion, with massage and the application of heat.

Restoration of function is good, though full recovery of motion may be slow. Permanent functional damage is rare. The deformity remaining is one of thickening, and sometimes of lateral distortion, familiar to all of us in this country, as exemplified in the hands of the old-time base-ball catchers. The permanent thickening about the joint is the rule, but not always present.

Fig. 672.—Location of the *joints*, distinctly below the corresponding skin-folds (diagram).

The statement has repeatedly been made that these luxations show under the *x*-ray a fracture luxation with a considerable bone fragment torn loose. I have found a small scale torn loose in two cases only out of many cases skiagraphed. Until further proof is forthcoming, it is fair to say that this possible lesion affects neither treatment nor prognosis.

Subluxation of Phalanges with Tendon Rupture

This is so distinct in its seriousness that it deserves a separate heading. The seriousness of the injury is due to the fact that both on the

* Dislocation of the thumb at the metacarpo-phalangeal joints is treated in Chapter XVIII.

flexor and extensor sides the tendon insertion into the last phalanx is indistinguishable from the capsule, and they may give way as one structure.

This not rarely happens on the extensor side.

Fig. 673.—Lateral luxation of a phalanx. Sketched from a case of the author's. Luxation readily reduced by traction and rocking.

The mechanism seems to be that of a sharp forced flexion of the last joint, with the next joint fully extended or hyperextended.

Fig. 674.—Subluxation of terminal phalanx of middle finger, with rupture of the extensor tendon at the joint. Sketch from a case (courtesy of Dr. H. A. Lothrop).

The clinical appearance is as shown in Fig. 674. There is no real luxation. The last joint can be straightened easily, but *not* by the patient's own muscular efforts.

There is little reaction of swelling or pain.

As the gap lies open into the joint, there is little tendency to repair even under fixation.

Operation is called for: not seldom the condition found is a *tearing out* of the tendon insertion, rather than a rupture of the tendon as such; this makes suturing difficult. I have known the operation to fail in the hands of competent men, but in fresh cases it is usually entirely successful.

In inveterate cases amputation may be preferable to the very bothersome, though slight, deformity.

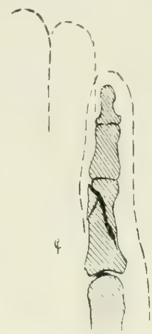


Fig. 675.—Fracture of phalanx.

FRACTURES OF PHALANGES

These are almost always the result of direct violence.

They are very largely the result of industrial accidents, and naturally are very often compound.

Being the result of blows or crushing, they follow no definite types.

Diagnosis is made by tenderness, mobility, crepitus (by inspection in the compound cases); as a rule, the x-ray is superfluous.

They call only for decent reposition and a splint.

Even the compound cases usually do well unless violently septic.

Necrosis, even of chips of bone, is not the rule.

The desirable splints are shown in Figs. 646 and 666. A straight "finger splint" may suffice.

Fig. 676.—Fracture of phalanx.

Fig. 677.—Fracture of phalanx.

Fig. 678.—Pathologic fracture of phalanx; spontaneous fracture in a case of tubercular dactylitis.

Union is usually prompt (three to four weeks); delay of union in clean cases I have seen only rarely and only in fractures of the last phalanx, where accurate fixation was hardly possible.

Delayed union, of course, accompanies sepsis. Non-union seems not to occur.

End-results are uniformly good unless we get projection of fragments on the *palmar* side. This, as with the metacarpal fractures, gives pain from gripping hard and interferes with manual labor.

Phalangeal fractures usually do fairly well, even if compound and septic, but compound dislocations or fractures that involve the joint,

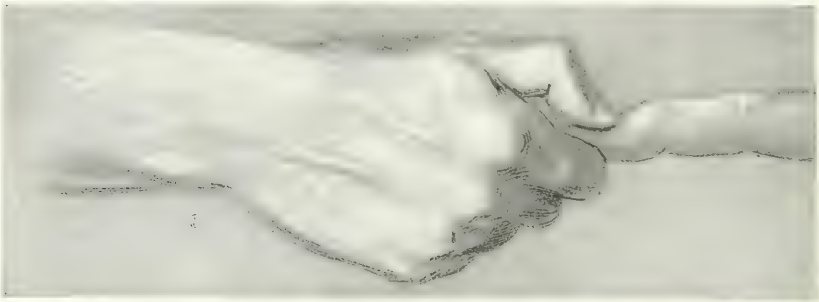


Fig. 679. Grip for reduction of phalanx fracture or luxation.

that become septic, do badly. As a rule, convalescence is so slow in these cases and the results are so poor that amputation is preferable to long waiting.

EPIPHYSEAL SEPARATION

This is but a variant of fracture, practically.
Such a case is shown in Fig. 680.

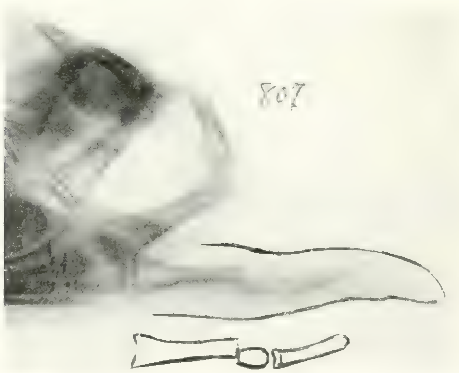


Fig. 680. Separation and backward displacement of the epiphysis of the first phalanx of the index-finger.

The epiphyses play but a slight rôle in hand injuries, considered from a practical point of view.

CHAPTER XX

PELVIS: FRACTURES AND LUXATIONS

Fractures of the pelvis are not very rare—by no means so rare as seems generally to be supposed, nor necessarily so serious.

The obviously severe fractures are rather uncommon, though, as Paul* has pointed out, not even these are rare in certain mining towns, etc. In the big city hospitals such cases occur less commonly, but the less severe cases are by no means uncommon. At the City Hospital in Boston I see certainly four or five cases a year, and this is only on one of three surgical services during a part of the year. It seems likely that these fractures may readily be overlooked where no serious damage to soft parts results. The diagnosis is not always easy in such cases.

There are many forms of pelvic damage, differing so much in cause, in prognosis, and in treatment that they must be considered separately.†

Fractures of the pelvis, with the exception of injuries to the iliac spine and crest, represent a smashing, at one or more points, of the irregular bony ring which surrounds and protects the pelvic viscera and transmits the weight of the body to the hip.

With fracture of this protecting ring the liability of the viscera to damage is obvious.

Such damage and associated injuries are the reason of the high mortality in these fractures.

Fractures of this protecting ring may be from direct crushing force, or may result from force transmitted through the femur by a blow on the trochanter, or even in falls on the feet.

Fractures and fracture luxations of the pelvis may be divided into—

1. Fractures through the rami.

2. Fracture through the rami with fracture near the sacro-iliac joint, or with diastasis of that joint.

* Paul, Ann. Surg., 1901, xxxiii, p. 733. He reports 54 cases from the hospital at Hazelton, Pa., in the heart of the coal-mining district. It is interesting to note not only the frequency of pelvis fractures in the mines, but their severity. In his series the mortality was 50 per cent., and the series shows five ruptures of the bladder, nine ruptures of the urethra, and one rupture of the rectum, with many other severe complications.

† One article of the few that recognizes fully the great *variety* of pelvic fractures is an admirable study by Simon (of the Insurance Hospital in Neunkirchen) that appeared in Bruns' Beiträge, 1905, xlv, p. 555.

3. Separation at, or fracture near, the symphysis (with or without sacro-iliac lesion).
4. Fracture of the acetabulum.
5. Fracture penetrating the acetabulum.
6. Fracture of the tuber ischii.
7. Fracture of the iliac crest.

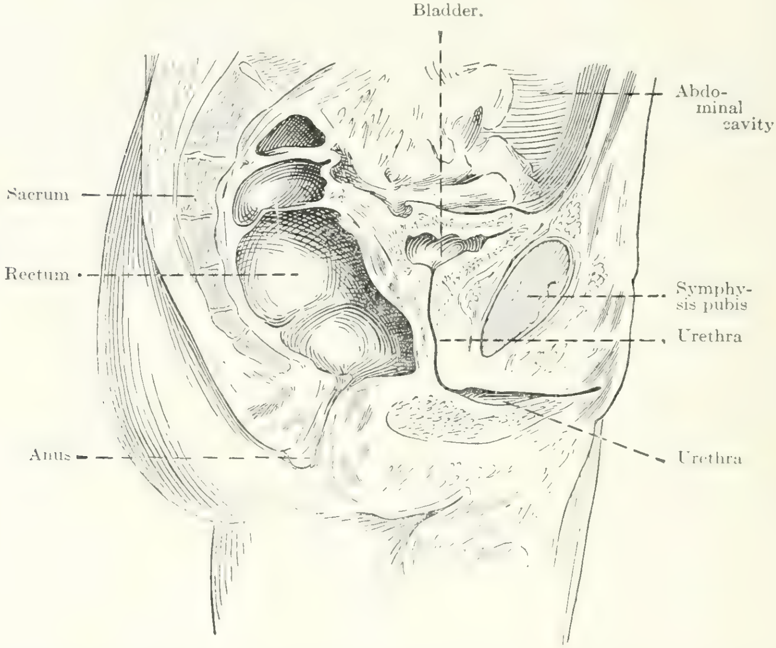


Fig. 681.—Median section of male pelvis. Notice close relation of bladder and urethra to the symphysis pubis. Fracture of pubic bone may injure bladder or urethra (frozen section by Professor Thos. Dwight).

8. Fracture of the anterior superior spine.
9. Sacro-iliac lesions alone.
10. Sacral fracture.

FRACTURES THROUGH THE RAMI

These occur either as a result of direct violence, from force applied to the pelvis from the front, or from lateral compression of the pelvis—a less degree of the force that causes the fracture of class 2.

There may be fracture of the rami on both right and left.

The more usual sites of fracture are indicated in Figs. 682, 687. There are apparently no typical *lines* of fracture, only a general approximation to a cross-break through both rami. There may be simply

fracture of the pubic ramus alone. Sometimes we have a double fracture in front, involving only the horizontal ramus.

Displacement is not ordinarily great—in fact, it is very little at the time of our examination. It seems fair, however, to assume always that displacement has been greater at the time of the trauma, and that there has been some measure of elastic readjustment. It seems probable that such *transient* displacement explains the frequent associated tearing of bladder, urethra, etc.

For it is not very rare to find in these cases an associated tear of the bladder, extraperitoneal or intraperitoneal; even oftener there is a tearing of the deep urethra. These tears are evidenced by the usual signs,

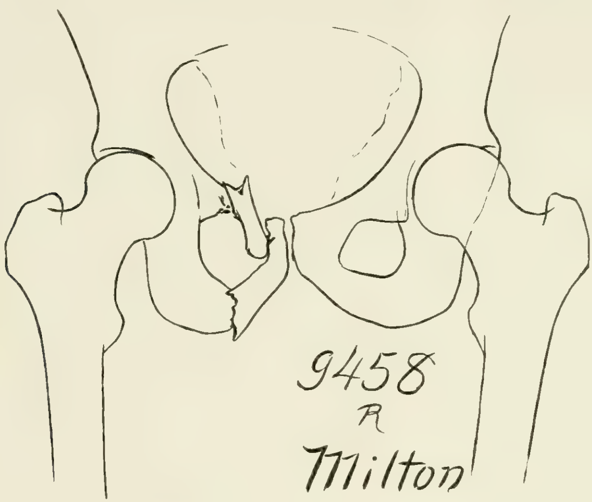


Fig. 682.—Fracture of rami of ischium and pubes on the right. Much displacement of the pubic fragment. Showed palpable fragment in the groin. Recovered practically without lameness.

but the presence of pelvic fracture should put us on the lookout for them.

Diagnosis is made on—

a. History.

b. *Local* tenderness.

c. Ecchymosis in front (in absence of signs or history of *direct* blow).

d. Mobility } both rather

e. Crepitus } uncommon.

f. Pain on pressure on the *sides* of the pelvis (Fig. 683).

g. Pain on push or pull on the pelvis transmitted through the leg (Fig. 684).

h. Pain on forced flexion or extension of the hip.

i. Displacement shown by vaginal or rectal examination gives excellent information as to the ischial ramus and tuberosity.

I have found signs *f*, *b*, and *c* most serviceable.

Of course, deformity, mobility, and crepitus are absolutely conclusive when they can be obtained by direct or bimanual examination. The presence of damage to bladder or urethra points very strongly to pelvic fracture.

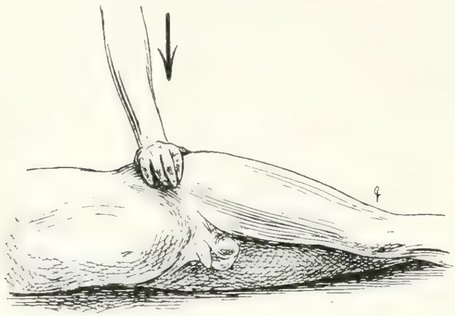


Fig. 683.—Lateral pressure on the pelvis just above the trochanter develops pain in most cases of pelvic damage.

As a rule, we will obtain confirmation of details by the *x*-ray, but the diagnosis may ordinarily be made without it.

Reduction.—No reduction is ordinarily needed. In case of upward or downward displacement or of rotation of a *loose* fragment (in comminution) we may attempt replacement by direct manipulation. I have tried it, but without any certainty that I had improved the existing position.

Treatment.—Rest and immobilization by means of a snug swathe about the hips, preferably a laced or strapped canvas swathe, is all we need in simple cases, or simple sand-bag support may be sufficient and more comfortable (Fig. 686).

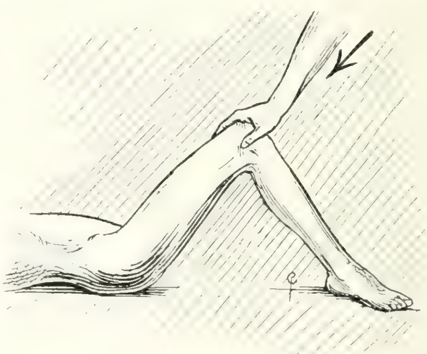


Fig. 684.—Pressure upward in the line of the thigh shows localizing tenderness in nearly all pelvic cases.

In cases of bladder rupture, torn urethra, vessel trauma, etc., the treatment is that of the complication—the fracture becomes secondary, and to be looked to later.

At the time, the fracture in such cases is important only in that there is necessarily extraperitoneal blood-clot. Such cases do, in fact, give a mortality corresponding to the visceral lesion *plus* that of the frequent infection of the fracture made compound by the drainage of the bladder or urethra. Add to this the element of shock of the injury or associated lesions, and the high mortality needs no explanation.*

*There are, however, many cases of recovery despite these complications; for instance, J. R. Eastman, of Indianapolis, in a recent paper (published in abstract in

In simple cases fixation should be kept up three weeks at least. What we accomplish by the swathe is simply immobilization and support: At times it is worth while to supplement this support with pillows or sand-bags at the sides, supporting trochanters and iliac crests from behind. Patients with pelvic fracture are apt to have a good deal of pain for the first part of the bed treatment.

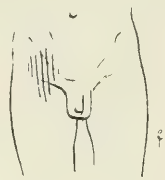


Fig. 685.—Site of ecchymosis with fracture of the rami.

Results.—I have had the curiosity to look up end-results in some of these cases, and have been surprised at the recovery of function. Save for some slight and inconstant weakness and occasional pain, referred to the region of the fracture, there seem to be no sequelæ.*

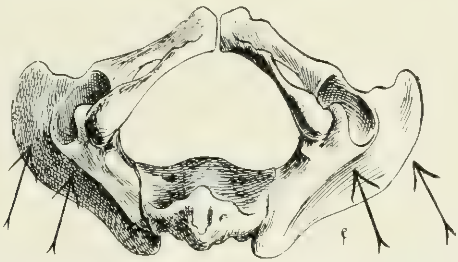


Fig. 686.—View of the pelvis from below. The arrows show the joints and direction of the supports to the pelvis. The usual sites at which sand-bags are to be placed.

Even where there remains much obvious thickening or even local deformity, we have no symptoms.

The results of associated bladder or urethral rupture are noted above.

FRACTURE OF THE RAMI WITH FRACTURE POSTERIORLY OR WITH SACRO-ILIAC SEPARATION

This is the type described as the "double vertical fracture of Malgaigne," named after its first historian.†

This injury consists of a breaking of the pelvic ring at at least *two* points, front and back. (See Figs. 688, 689, 690.)

the St. Louis Med. Review, November 4, 1905), reports three cases of bladder rupture—extraperitoneal—with recovery, and discusses symptoms and treatment.

Hugh Cabot, of Boston (Ann. Surg., January, 1909), reports a case of fracture of the rami on one side, in which G. W. W. Brewster did an immediate perineal section for urethral rupture. Cabot later did a plastic operation for urethral repair with success.

Delore (Lyon méd., 1905, cv, 964), in a like case, did retrograde catheterization and external urethrotomy with success.

* Cohn (Bruns' Beiträge, 1905, xlv, p. 545) cites a case of a girl of sixteen who had had a fracture of the ramus (from being run over) at sixteen months of age. The right ramus was *ligament with almost no bone;* there was *no* disability.

† What Malgaigne described was the break front and back on *one* side. Malgaigne: "Treatise on Fractures," American edition, 1859 (Packard), page 525.

The lesion at the back may be a break through the ilium or a dislocation or fracture-dislocation at the sacro-iliac joint.

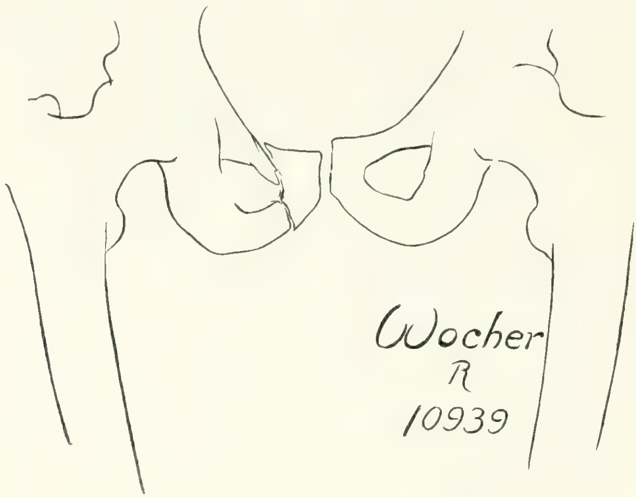


Fig. 687.—Fracture of both rami on the right. It will be noticed there is a shifting of the left pelvis as a whole upward and to the right, which could not be equalized by traction. Recovery only partial on account of apparent failure to recover strength at sacro-iliac joint. No trouble at point of fracture.

The damage results from a crushing of the pelvis, as a whole, laterally or anteroposteriorly, or from *rolling* of the pelvis under heavy pressure. "Cave-ins" of dug banks, or of buildings, or car accidents, are the common cause.

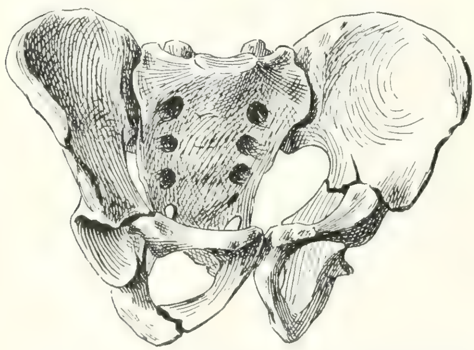


Fig. 688.—Fractured pelvis; on the right, fracture across pubes and ischium; on the left, fracture involving acetabulum and sacrosciatic notch (Warren Museum, specimen 3857).

Fig. 689.—Double vertical fracture of Malgaigne; fracture of the rami combined with fracture or joint-separation at sacro-iliac symphysis—on one or, as in this case, on both sides (sketched after Cooper's plate).

If there be a double break, front and back, on the same side, all bony support of the pelvic ring is lost on this side, and considerable

displacement is not infrequently found. There is also a greater possibility of displacement *inward* than in class 1.

If there is fracture in front with sacro-iliac separation behind, or if the lesion in front is a separation of the symphysis, there *may* be a

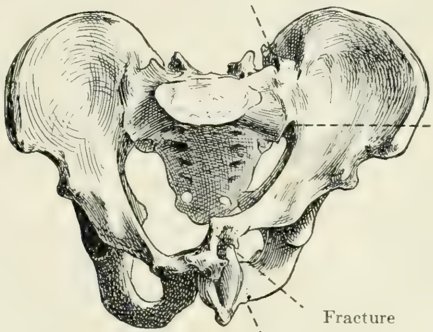


Fig. 690.—Fracture of rami of pubes; fracture and separation at sacro-iliac synchondrosis; much displacement; bony union (Warren Museum).

similar *upward* displacement.* With fracture on opposite sides, front and back, we get no such displacement, of course.

Fracture, bilateral in front or behind, or both, is rarer. It occurs usually only with hopeless crushing and with associated visceral damage.

With all cases where there is any combination of fracture in front with damage behind, ruptures of the bladder and tears of the urethra are rather common, and we have the added possibility of tearing of the rectum, in this class.

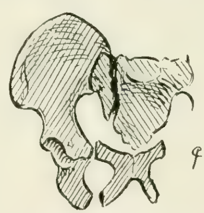


Fig. 691.—Double vertical fracture of rami on both sides, with fracture of the sacrum instead of sacro-iliac separation (sketch after Stimson's plate).

Diagnosis.—All the points enumerated under class 1 (fracture of pubic rami) have their bearing also on class 2.

In addition we may have:

(*a*) Displacement, sometimes very obvious, of the whole of one side of the pelvis, upward. *No* measurement shows this. The *x*-ray is our only absolute proof.

(*b*) Mobility of this side of the pelvis on the other on intermittent traction on the leg.

* Creite (Deut. Zeit. f. Chir., 1906, lxxxiii, S. 391) reports an autopsy case of this sort. There were no intrapelvic lesions. Death occurred from delirium tremens and sepsis at six days. The autopsy showed a separation of $3\frac{1}{2}$ cm. at the symphysis, and an entire loosening of the sacro-iliac joint on the right, with $\frac{1}{2}$ cm. separation. The whole of this side of the pelvis was movable.

The author also cites a number of like cases in the literature.

(*c*) Local pain and tenderness, and sometimes ecchymosis, near the posterior spine of the ilium.

(*d*) Pain posteriorly, as well as in front, on *bilateral* pressure on the iliac crests.

(*e*) Mobility of one part on another (crepitus rarely) on manipulation.

There should ordinarily be no question of the gross diagnosis, even

Fig. 692.—Fracture of both rami on one side, with separation of the symphysis. In this case there was some opening out of the pelvis as a whole, as well as marked rotation of the broken pubic portion. Except that the gap could be felt and there was some ecchymosis, there was very little to show for the lesion clinically. The patient died of delirium tremens before any question of repair could be considered (case seen by Dr. E. H. Nichols, to whom I am indebted for the plate).

without the *x*-ray, which is, of course, desirable for purposes of detail and of record.

Treatment.—Ordinarily, the treatment need be only that advocated for fractures of the pubic rami alone unless there are complications.

There is here, however, an added item, namely, *vertical* displacement. This is to be overcome only by traction.

Traction in such case (by the usual Buck's extension) I have used and found serviceable; weights of at least 20 pounds are required.

Results.—Many cases die of shock or of complications.

If the patient recovers, in case we are dealing with double fracture,

consolidation becomes firm and the sequelæ about as in class 1. Where there is fracture forward,—sacro-iliac diastasis aft,—we have a less solid healing. In two of my cases of this sort there was a complaint of pain in sleeping on either side—*more* from sleeping on the sound side—and moderate disability as to walking and lifting. Such part of the shortening as has not been overcome by traction ordinarily gives some little disability.

To sum up, it is fair to say that these cases rarely, if ever, escape *some* disability with a slight limp and local soreness after exertion, etc., but, on the other hand, we do not find such disability as to interfere with moderate work and moderate use of the limbs.

SEPARATION OF THE SYMPHYSIS

Separation or subluxation of the symphysis alone is a postobstetric condition, not a traumatic one, as a rule.

Its diagnosis depends on local pain and mobility. The pain is brought out by direct pressure, by alternate pull and push on the thighs, and particularly by forced abduction. There is obvious ecchymosis in this region in some cases.

Fig. 693.—Total displacement upward of entire one side of pelvis, with separation of symphysis and of sacro-iliac joints. No fracture (diagram).

There may be gross and palpable separation; this is rare.

In one case seen the damage resulted from a fall in which the legs were widely spread. He had great sensitiveness in the region of the symphysis, and about the adductors, close to the bone. There was some ecchymosis. Mobility at the symphysis was so slight as to be doubtful, but attempts to bring it out were very painful. Rest in bed, with the wearing of a pelvic girdle, brought about prompt and entire recovery.

Most of the recorded cases have been of this type as to causation and symptoms.* A curiously large proportion have resulted from accidents of one sort or another in the saddle.

Separation may be considerable, but is not usually great. The

* A case reported by Le Gros Clark (quoted by Stimson), for example, had a four-inch separation at the symphysis, with gaping of sacro-iliac joints on both sides, with various fractures also. There were also ruptures of the rectum and of the bladder, and the urethra was torn loose from the prostate. Obviously, in such cases, the bone damage is a detail merely. Other like cases have shown laceration of the iliac artery or vein.

point of separation is said to be not through cartilage, but between cartilage and bone. Fractures may occur very close to the symphysis.

Separation of the symphysis may be combined with various fractures or with sacro-iliac separation of one or even of both sides. Such injuries are, however, very rare.

A few cases are on record in which such lesions have been associated with a direct shifting upward of one side of the pelvis, as a whole,—an actual double luxation,—a lesion obviously to be diagnosed by palpation, a lesion, by the way, proved not so dangerous as it sounds.

Treatment.—The treatment is by pelvic girdle or jacket, or rarely by wiring together the two sides of the symphysis.*

Reduction of any *vertical* displacement is obviously indicated. Reduction is by traction.

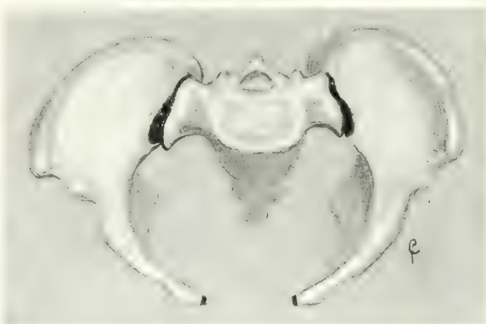


Fig. 694.—Opening out of the front of the pelvis, with tearing at the symphysis and diastasis at the sacro-iliac joints (diagram).

Prognosis.—Symphysis separation *per se* is not ordinarily a serious injury. Symphysis separation with complications obviously carries the risk of these complications, hence the statistics show a considerable mortality.† Union of the symphysis in these traumatic cases is satisfactory and function is good, as a rule.

FRACTURE OF THE ACETABULUM

That fracture of the acetabulum, especially of the back edge, may occur, is beyond doubt. Such fracture is essentially a complication of posterior luxation of the hip.

* Since the above was written I have wired one case of symphysis separation. The interval was originally 1½ to 2 inches. The tearing was between cartilage and bone, with great periosteal stripping. The denuded bladder was intact.

† Cohn (Bruns' Beiträge, 1905, xlv, p. 589) cites one case of his own and 14 from the literature. Of these, there were 6 cases of bladder ruptures. In 1 there was clot suppuration with prompt recovery on incision; 8 cases recovered. In 4 the recovery was perfect; in 3 almost perfect; in 1 the result is not stated.

Le Gros Clark has called attention to the frequency of clot suppuration in the pubic injuries (cited by Stimson).

Its existence is inferred from: (*a*) Crepitus in reduction; (*b*) recurrence after reduction.

There are no signs beyond this, unless the skiagraph happens to tell us something. The diagnosis is largely a matter of inference.

Reduction.—Effective reduction of a reluxated hip, and fixation in the reduced position for more than the average time, constitute our means of defense.

So far as can be learned, these means are efficient.

Reluxation of the hip or chronic luxation is, at the worst, excessively rare.

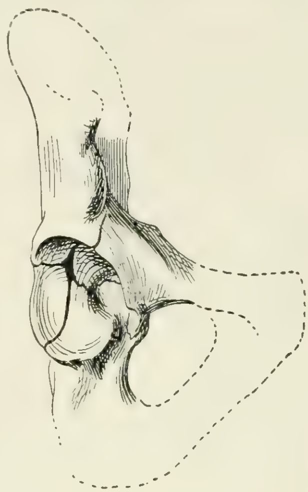


Fig. 695.—Fracture of acetabulum; force transmitted through femur (Warren Museum, specimen 1053).

FRACTURES THROUGH THE ACETABULUM

Of this lesion we have two forms—a smashing of the acetabulum and a penetration of the joint by the femoral head ("*central luxation*").*

The simple smashing apparently occurs from force exerted through the femur, not severe enough to drive the head through. As to lines of fracture, information given us by the x-ray in two cases of mine and two published plates seems enough to suggest, if not to prove, a general type—a fracture line oblique upward and forward.

In younger patients the lines of epiphyseal junction may be followed.

If we have mere smashing without penetration, there are but a few signs, namely:

(1) Lateral mobility in the joint, brought out by shoving on the trochanter and pulling out on a perineal sling, alternately.

(2) Possible crepitus on this test or on flexion and extension, or on rotation of the leg as a whole.

No landmarks seem to be of use. In only one case of mine the diagnosis was made *beforehand* on the above signs (with sign No. 2 doubtful), and was confirmed by the x-ray.

There is not necessarily any shortening.

The trochanter may be less than normally prominent.

The lesion is likely to be confused not with other pelvis fractures, but with fractures at the hip. As distinguishing signs, the following may be given:

* Of recent reported cases, may be cited: Wilms: Deut. Zeit. f. Chir., 1904, lxxi, Nos. 5, 6. Schroeder (49 collected cases): ref. in Jour. Amer. Med. Assoc., August 7, 1909. Arregger: Deut. Zeit. f. Chir., lxxi, Nos. 5, 6, 1904, S. 487. A. E. Halstead: New York Med. Jour., Nov. 13, 1909, p. 953.

Fracture through the Acetabulum.—

(*a*) No shortening—or next to none.

(*b*) There is no disturbance of landmarks save for less prominence of the trochanter.

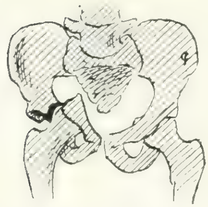


Fig. 696.—Central dislocation of the head of the femur, with acetabular fracture (sketched after Simon's plate).

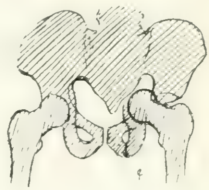


Fig. 697.—Central luxation of femur into pelvis (sketched after Arregger's *x*-ray).

(*c*) There is not apt to be any fixed inversion or eversion.

(*d*) Mobility of the joint is pretty near the normal.

Hip Fracture.—

(*a*) Restriction of mobility characterizes *impacted* fracture of the femoral neck.

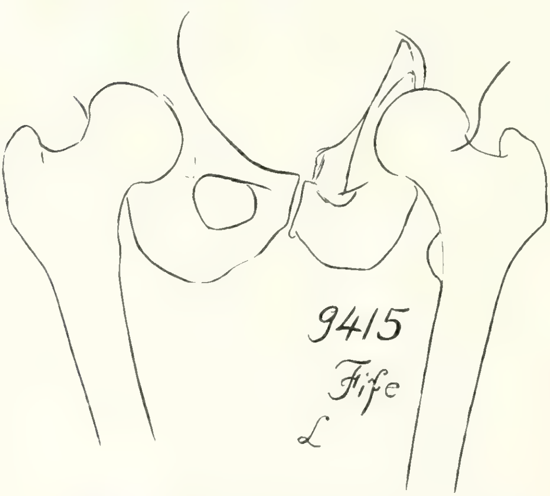


Fig. 698.—Head of the left femur has been driven into the pelvis, breaking the rami and carrying the floor of the acetabulum in front of it. Case of the author's. There was a little shortening, some limitation of hip motion, but substantially perfect result.

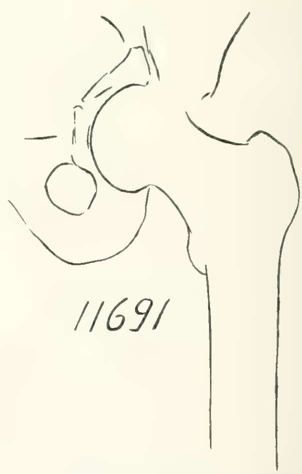


Fig. 699.—Fracture similar to previous plate; whole floor of acetabulum driven into pelvis. No complications. Clinical result good.

(*b*) Loose mobility with outward rolling of the foot belongs to *unimpacted* fracture of the neck.

(*c*) Crepitus tells nothing as between loose neck fracture and the acetabular lesion, but—

(*d*) There is always up and down mobility in loose neck fracture, and it is easily demonstrated, as a rule, by intermittent traction downward. Sometimes, however, muscle spasm hinders this test unless ether is given.

Reduction Treatment.—To be guided by the *x*-ray.

Mostly there is nothing to reduce. If there is, strong traction down and out is indicated.

Obviously, immobilization is called for.

I have used moderate traction (Buck's extension) also, and in one case (see foot-note) lateral traction outward as well, to overcome the tendency to displacement inward.

The tendency is to rapid healing.

Results.—I know nothing in detail except as to two cases of my own. Of these, one had some little stiffness. The other showed an absolutely *perfect* result.*

Fracture with Penetration of the Acetabulum: "Central Luxation of the Hip"

Rarely, cases are recorded in which the head of the femur has not only split the acetabulum, but has actually penetrated it, so that the head comes to lie inside the pelvis. Great force is required, and there are very apt to be intrapelvic complications, often fatal.

Despite certain classifications of recent years, "central luxation of the hip" is not to be separated definitely from acetabular fractures with fractures through the arch. Penetration of the pelvis by the femoral head may occur with very extensive associated fracture or without any;† when the acetabulum is smashed in, the pubic arch must give way almost necessarily.

For the mechanism of this fracture we have little to guide us save an experiment by Virevaux, who succeeded experimentally in producing

* J. E.: Fall from a second-story balcony, April, 1908. Fracture left pelvis. Clinically, there was slight pain only, with questionable shortening, and, on lateral pressure on the trochanter, a displacement of 1/2 to 3/4 inch inward, with a *distinct, soft* click. Provisional diagnosis, fracture of rim of acetabulum. Very slight swelling and ecchymosis about the region of the femoral vessels. The *x*-ray shows a fracture of the pelvis just anterior to (possibly through) the acetabulum.

As soon as this diagnosis was made and confirmed, the treatment was instituted of longitudinal traction with outward traction exerted by a band across the adductors, to which a pulley-weight was hitched.

An *x*-ray plate of May 11th showed an entire disappearance of the deformity shown in the first plate. On examination there is now no click or mobility. The apparatus was removed at the end of four weeks.

May 16, 1908: Up in a chair.

September, 1908: Walking about with limp or shortening or limitation of motion. Is at work. A perfect hip.

January, 1909: Is working as a teamster without any disability. All motions of the hip are normal.

† There is a central luxation of the hip recorded in which the head is driven through the obturator foramen.

this lesion by force applied to the trochanter directly, without abduction or adduction of the limb. In three other like experiments he succeeded in producing acetabular fractures, but without penetration. It is certain that the force is necessarily applied through the femur, though not necessarily through a blow on the trochanter. For instance, in Krönlein's case,* the only case on record of *bilateral* "central luxation," the injury resulted from a fall in which the patient landed on both feet.

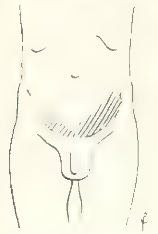


Fig. 700.—Area of dullness to percussion from extraperitoneal hemorrhage in pelvic fracture.

The lesion varies, of course. Essentially it does not differ from that of the smashing of the acetabulum in which the force has not sufficed to produce penetration.

As to lesions of soft parts, we may have none, for the pelvic fascia is strong. Rupture of the gut has been recorded as a complication of the penetrating lesion.

There is a case on record (Morel-Lavallée) where the autopsy showed not only penetration of the pelvis, but also direct pressure on the obturator nerve, explaining the severe pain complained of.

Diagnosis.—The signs given for acetabular smashing without penetration are equally cogent here. The loss of prominence of the trochanter, the slackening of the tense fascia lata, etc., are present in even greater degree.

There may be outward rotation, with loss of movement at the hip, but, on the other hand, the position may not be abnormal at all, and motions may be very free.

Rectal examination showing the prominence of the head (and possibly its rotation with the shaft) may be of assistance in diagnosis.

Fig. 701.—Reduction of the central luxation by pulling out on the upper end of the femur by means of a sling in the groin, with countertraction on the pelvis; at the same time moderate traction and rotation exerted downward in the axis of the thigh.

There is apt to be, in these cases, a good deal of intrapelvic hemorrhage, not necessarily involving large vessels. The only sign of this is dullness on percussion about and above the groins.

The sketch shown in Fig. 700 shows the sort of pattern of dullness

* Krönlein: "Die Lehre von den Luxationen," Deut. Chir. 1882, Lief 26, S. 25.

we are apt to find. This case was a fracture of both rami, not of the acetabulum, but the pattern will serve.

Treatment.—Obviously, it is desirable to reduce the displacement of the femoral head and then treat the fracture of the pubic arch in the usual way.

This does not seem to have been the treatment of record in the cases of which I have seen the reports, but this is mainly, no doubt, because the cases have not been seen early, or, if seen early, have been in no condition for active interference.

Reduction must obviously be by traction down and out, with rotatory movements to clear the way. A cushion between the legs to act as a fulcrum over which the head of the bone may be pried out, has been suggested.

Katz* has proposed reposition by pressure from the rectum. This seems probably impractical (there are no cases to support it), and it seems possibly apt to inflict further damage; force exerted through the femur seems *more promising.*

Simon (*loc. cit.*) says that only light traction is indicated, and that the therapy is that of pelvic fracture in general, and not directed to this particular lesion. I can recognize no treatment of pelvic fracture *in general;* it seems to me that we must individualize more.

It seems probable that *traction* on the femur *downward and outward would render after-treatment more effectual.*

Prognosis.—The possibility of good functional results in such cases is illustrated by Lendrick's case,† in which a man no longer young was involved in the overturning of a coach, but had so recovered as to be able to take long tramping trips in German fashion. He died of phthisis, and the autopsy showed the femoral head driven through into the pelvis, where a new bony cavity had been formed. Both pubes and ischium had been smashed.

FRACTURE OF THE TUBER ISCHII (ALONE)

I have no doubt that this fracture may occur. I have seen a number of cases in which this diagnosis had been made, but none in which it was justified; in each case the skiagraph proved a fracture of the *pubic* as well as the ischial ramus.

Obviously, a real fracture loosening the tuber ischii could be *definitely* detected by bimanual examination, *i. e.*, with the forefinger in the rectum and the thumb (and the other hand) outside.

Treatment could do nothing beyond immobilization, and for this purpose rest in bed with *any* apparatus securing the comfort of the patient would suffice.

* Katz: Bruns' Beiträge, 1902, Bd. xxxiii.

† Quoted by Hamilton : "Fract. and Dislocations," third edition, 1866, p. 341.

I know nothing of the results: there is no obvious reason why they should not be good.

FRACTURE OF THE ILIAC CREST

These fractures are rather common. They occur always, it seems, from *direct* violence exerted, as a blow or as pressure, from the side.

The lesion is a separation of the iliac crest through any part of its length (see Fig. 702), and to a varying depth. I have seen one case in which there was at least a suspicion that the separation was of part of the narrow shell of epiphysis that runs along the crest.

Displacement is always inward.

Diagnosis rests on the local soreness and swelling, on the palpable displacement, on crepitus, and, *for confirmation*, on the x-ray.

Fig. 702.—Fracture of crest of ilium (Warren Museum, specimen 5938).

Mobility and crepitus are obtainable only very early; this fracture "glues down" very early (like breaks of the nose, of the ribs, etc.).

Treatment.—Real reduction seems to be impracticable. The best thing to be done is to secure rest. A *tight* swathe must obviously *increase* displacement by pressure toward the middle line. The best thing that we can do, therefore, is to immobilize with a *loose* swathe and support the fragment with pillows and sand-bags.

As noted above, fixation by callus occurs early. When it has occurred, a tight swathe can do no harm and is comfortable.

Fixation must be continued until consolidation is firm enough to resist the pull of the abdominal muscles which are attached to this edge of the ilium. This means three to four weeks.

Results.—Apparently, no disability occurs beyond temporary soreness. Some deformity may persist, but is usually slight, and seems to be of no consequence.

SEPARATION OR FRACTURE OF THE ANTERIOR-SUPERIOR SPINE

A rare injury. The one case I have seen was, like all those reported, from muscle action. The process gives origin to the powerful sartorius muscle. In this case the man—a young fellow of nineteen years—was sprint-racing, when "something gave way." He did not fall, but could not run the race out. When seen, he showed a slight thickening below

the normal side of the iliac spine, and a movable fragment could be made out, displaced downward, but not displaced far. There was pain on active attempt to lift the thigh, as well as on pressure on the injured region. Fixation gave prompt union (perhaps fibrous, but solid), and he soon regained approximately normal use of the leg.

The lesion seems not to be one of any gravity as to end-results.

CHAPTER XXI

LANDMARKS OF THE PELVIS AND HIP

Landmarks.—Externally, we may readily distinguish—

Anterior-superior spine.—Its position is obvious save in very stout persons, in whom it may be overlaid with pendulous abdominal fat, which must be lifted up before it can be found. (See Figs. 703, 704, 705.) The "spine" is not always sharp; sometimes it is not even definite enough to give an accurate point of measurement, but it is always palpable.

Fig. 703. Landmarks of the front of the pelvis, as seen in the moderately stout, middle-aged man. The crosses show anterior-superior spines and pubic spine; the line is that of Poupart's.

The *pubic spine:* the outer termination of the rough superior border or crest of the symphysis pubis.

Poupart's ligament, connecting the iliac and the pubic spines.

Symphysis.—The symphysis is always palpable, but too vague in outline to be of much use as a landmark.

Ramus of Ischium.—This is always palpable —externally in the perineum, internally per vaginam or by rectum.

Tuber Ischii.—Always palpable, but under heavy fat masses it is very apt not to be useful for measurements.*

Posterior-superior spine, the back end of the iliac crest—not always palpable, but the most distinct prominence posteriorly.

Trochanter Major.—Palpable always as a bony point of resistance; usually its outlines may be made out. Its normal relations are indicated in Fig. 706.

Often the *digital fossa* may be made out. (See Fig. 781.) The fact that it is a definite hollow on the sound side, not on the injured one, is of value as showing damage, particularly in hip fractures.

Front of Joint.—The anterior portion of the hip has no landmarks, properly speaking, but marked fullness over or near the joint (see Fig. 783) is of value as indicating probable fracture of the neck or, rarely,

* The tuber ischii and the ramus of the ischium are always palpable by rectum or vagina—a point of no value in hip measurement, but often convenient in questions of pelvic fracture.

joint effusion. Fullness from these causes is lower down than that sometimes seen with fractures of the pubic ramus.

Fascia Lata.—The fascia is hardly a landmark, but the disappearance of the resistance it furnishes, as felt above the trochanter or near the knee (see Fig. 782), is proof presumptive of dislocation or of fracture somewhere between the hip and the knee-joint.

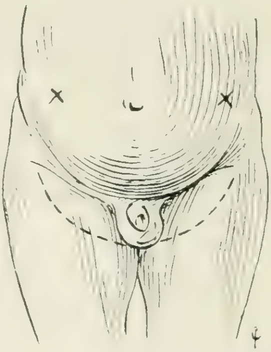


Fig. 704.—The landmarks in stout persons are found much higher than would be suspected —a common cause of confusion. In still stouter individuals the belly frequently reaches the level shown by the dotted line. It is not uncommonly necessary to lift the belly off the pubes to reach the landmarks.

Reference to the diagrams will make description of these landmarks and their identification unnecessary. It may be noted that the anterior-superior spine may be, in obese elderly subjects, far above the fold that usually corresponds to Poupart's ligament (see Fig. 704), and that in such subjects the pubic spine may only be discoverable by running the hand under the pendulous fold of abdominal fat.

In utilizing these landmarks we usually make the following routine examination in *every* case of suspected pelvic injury or hip damage. The patient is laid on the back, so that the hips lie square (a line between anterior-superior spines runs at right angles to the vertical line of the trunk and legs), and the pelvis lies flat on the table (*i. e.*, the lumbar region and the posterior spines nearly in contact with the table).

Then the position of the thigh is noted, whether flexed, abducted or adducted, or rotated in either direction, and we note whether this position is one of comfortable choice merely, or one fixed by muscle spasm or ligamentous or bony restriction.

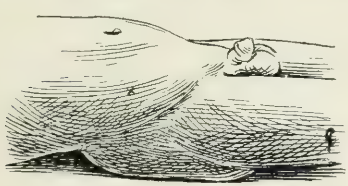


Fig. 705.—The relation of the anterior-superior spine to the fat-folds in a man of middle age (sketch from actual case on the table).

Then we measure the length of leg, measuring from anterior-superior spine to internal malleolus (or sole of foot at the heel) (Fig. 709).

This measurement to be of value must be with the pelvis square and with the two legs in like relation of angle to the pelvis. Any abduction or adduction changes the measurement (see Fig. 711), and with legs parallel, but pelvis not "square," the doubled error may be considerable.

Then we place the thumbs on the anterior spines right and left and palpate, first, the region above the trochanter, to determine the relative tension of the fascia lata, right and left; second, the trochanter itself,

noting displacement upward or outward or backward, also general thickening and obliteration of the groove at the back (the digital fossa), which is ordinarily to be felt even in fat people if felt for in this way.

The practised hand can almost instantly appreciate changes of relation in such examination. For the less practised hand and for purposes of record we have two artificial methods—the Roser-Nélaton line and Bryant's triangle. The Nélaton line, as it is usually called in this country, is a line drawn from the anterior-superior spine to the tuber ischii; during the drawing the hip is flexed 45 degrees. This line just strikes the top of the trochanter unless this trochanter is displaced.

The trouble with the line is that the tuber ischii is not always readily defined, and that even with the ends fixed, the line so drawn, across a fat hip especially, may vary greatly with variations in the position of the operator's head and eye.

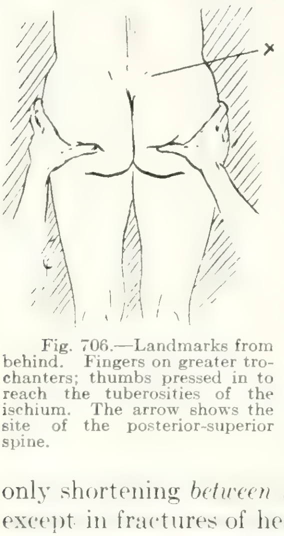


Fig. 706.—Landmarks from behind. Fingers on greater trochanters; thumbs pressed in to reach the tuberosities of the ischium. The arrow shows the site of the posterior-superior spine.

Anatomically, it is all right; clinically, it is nearly worthless, save in the hands of the expert who does not need it. (Fig. 710).

Bryant's "triangle," on the other hand, is of real use. This measurement is made by dropping a perpendicular from the anterior-superior spine, as the patient lies on his back, and marking it on the skin. At right angles to this line a line is drawn to it from the trochanter, and another line, completing the triangle, from trochanter to anterior-superior spine. (See Fig. 712.) The length of this last line varies with injuries, and the difference may be of use, but the second line, compared right and left, gives an absolute index of the amount of shortening. It measures only shortening *between* acetabulum and trochanter—*i. e.*, it is negative except in fractures of head or neck or dislocation, or the rare acetabular fractures. (See under Hip Luxations for illustrations.)

SACRO-ILIAC JOINT

This is a very strong articulation—one that, by its shape, permits little motion so long as *any* of its strong ligaments are intact. In serious fractures of the pelvis we may have diastasis of this joint as a complication.

Actual uncomplicated luxation rarely occurs in cases that survive the original injury. Now and again we see cases of *sprain* of this joint. They show local tenderness, pain on weight-bearing, pain on flexion of the hip, and pain on pressing in from either side on the iliac crests.

The lesion results from falls on or about the hip.

The treatment is rest in bed, with sand-bag support to the pelvis at either side, a pad or pillow under the lumbar spine, and a snug swathe about the hips; after this, support by a belt carried below the crest of the ilium on either side and worn tight is efficient (Fig. 708).

Fig. 707.—View from the inner side, showing the sacro-iliac joint; its comparatively small pear-shaped articular surface, and a much larger area behind it entirely devoted to ligamentous insertions.

The prognosis is good, recovery ensuing after lameness of some weeks.* There is little tendency of definitely traumatic cases to go on to the chronic sacro-iliac relaxation we sometimes see.

Chronic sacro-iliac luxation, or really *relaxation,* is more frequent. This complaint, well attested in certain cases, has attained a prominence of late which is probably in part fictitious —this prominence represents the usual psychic reaction when a condition previously ignored comes to be recognized.

In the clean-cut cases we have much local lameness and various radiating pains of hips and thighs, with much disability. Pain on pressure inward on the ilia, tenderness over the joints on either side, and relief of discomfort on applying support beneath the upper part of the sacrum as the patient lies on a table are the diagnostic features. The displacement seems to be usually a rocking *backward* of the sacrum in the iliac mortise.

Fig. 708.—The pelvic girdle.

The cases give at times a history of trauma, but the condition is one *essentially* dependent on the relaxation of the sacro-iliac ligaments, not uncommonly, perhaps not abnormally, associated with pregnancy or with general laxity of tissues. Trauma is not the common cause.

The treatment is rest in bed with sacral support, then application of some form of pelvic girdle to be worn until recovery is practically complete.

Sacro-iliac Luxation

This, or oftener subluxation, occurs not uncommonly as a complication of pelvic fractures, especially, it seems, in the cases of fracture of one or both rami, produced by anteroposterior pressure.

Similar damage may attend disastasis at the symphysis caused by

* In one case I have seen suppuration follow such a condition—suppuration in which no evidence of tubercle bacilli was found in pus, which was also sterile as to other organisms. This case is probably noteworthy only as a curiosity.

spreading of the legs. Such damage may be of one or of both sides. There is but one case (Dubreuil) of clean-cut diastasis of the symphysis and of *both* sacro-iliac joints. Even here there was associated fracture. Such diastasis, of one or both sides, calls for the application of a tight compressing swathe. All cases of *double* diastasis up to date seem to have been fatal from associated intrapelvic and intra-abdominal injury, or tearing of the iliac vessels.

In case we have diastasis of the symphysis in front and of the sacro-iliac joint of the same side behind, we may have a displacement not unlike that met with in "double fracture," namely, a displacement *upward* of the whole side of the pelvis. This occurs apparently from a fall on one foot, usually.* A number of such cases are on record. They are not necessarily very serious, except through complications.

Salleron† had two such cases which recovered after reduction.

Reduction is by traction downward by hand, kept up by weight extension. A weight of 25 to 50 pounds is not too much.

The cases are treated until union is relatively solid (*i. e.*, for about a month).

Results.—I have no experience with this lesion, and the cases recorded give little detail as to results. It seems unlikely that so extensive a lesion, even if well repaired, could ever fail to leave behind some sacro-iliac weakness at least, but the prognosis with tolerable reduction seems to be rather good.

Sacral Fracture

Sacral fracture is one variant in this general class of injuries of the pelvic ring. It occurs but rarely. The fracture is in approximately vertical line, close to the sacro-iliac joint. (See Fig. 691.) So far as published data go, it seems to have no direct signs by which we may distinguish it from fracture of the ilium just on the other side of the joint,‡ and it seems to differ in no way as regards prognosis.

* Earle: Med.-Chir. Trans., 1835, xix, 257.

† Salleron: Arch. Gén. de Méd., 1871, ii, p. 34.

‡ There *should* be liability to damage of nerves of the sacral plexus, but I have met no account of such a lesion, with the vertical fracture. It does occur with the independent *transverse* sacral fracture.

CHAPTER XXII

HIP DISLOCATION

Despite its prominence in the text-books and the literature, dislocation of the hip is an uncommon lesion. The fascination of the complicated problems of reduction has led to much painstaking research and

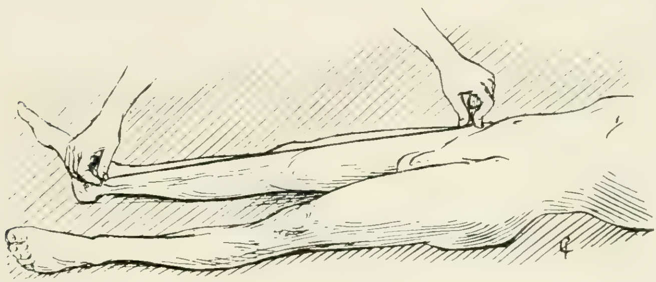


Fig. 709.—Measurement from anterior-superior spine to tip of internal malleolus.

to an emphasis which the lesion, from a practical point of view, hardly warrants.

The catalogue of the Boston City Hospital (an institution showing a very large array of unselected accident cases) shows, in the last twenty-

Fig. 710.—Nélaton's line. A line drawn from the anterior-superior spine to the tuberosity of the ischium, with the leg flexed at about 45 degrees, normally just strikes the top of the great trochanter (a measurement peculiarly liable to personal error as the line is drawn over curved planes).

eight years, 62 cases of hip luxation to 869 cases of *fracture* of the femoral neck; the possible error, owing to uncorrected provisional diagnoses and to enthusiasm for "operable" cases, would, if corrected, show an even smaller proportion of actual luxations.

Hip dislocations are characteristically a lesion of adult life, rare, though not unknown, in children.

As a consequence of their greater exposure to severe trauma, men, rather than women, are liable to the injury, and for the same reason young men and the middle-aged, rather than the more elderly.

The hip lesion that usually occurs in advanced years is not luxation, but fracture of the femoral neck; in the earlier years there is more nearly an even proportion between the two lesions.

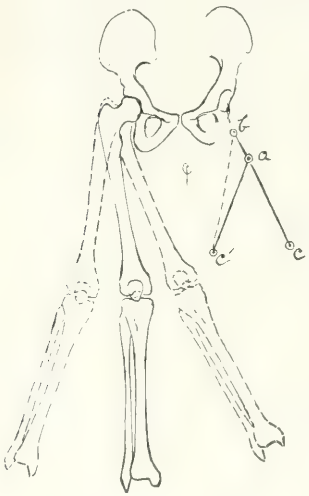


Fig. 711.—In measuring from the anterior-superior spine to the ankle there is a constant error, due to abduction or adduction. This is due to the fact that the anterior-superior spine does not lie in the line of the axis of measurement. A reference to the small diagram to the right will make it clear that for this reason the distance *b-c* in case the acetabulum *a* does happen to lie on the line of measurement will obviously be more than the distance *b c'*, which corresponds to the measure obtained in abduction. Naturally, when the legs lie parallel, shortening occurs on the right and lengthening on the left (and vice versa), so that the error is *doubled* and may be very considerable in amount.

Dislocations of the hip are safely divisible into posterior and anterior displacements. Beyond this the classifications diverge widely, and it is hard to be sure what is meant by the individual reporter, for some of the classes are based not only on the actual position of the femoral head, but also on assumptions as to *how* it reached this position.

The wise classification seems to rest on the *position* of the head.

That is about all we can make out. Theories of transit in rotation, etc., diverge too widely for consideration in practice.

It is not even worth while to be over-precise in classification of position. In any individual case the position is to some extent liable to change with—or even without—gentle manipulation. Moreover, very exact determination of position, even if possible, is of no moment so far as the all-important matter of reduction is concerned.

The type of displacement depends on the relation of the displaced head to the socket and to the ligaments.

Bigelow* has fixed for all time the very important rôle of the Y-ligament. The matter of first importance in luxation is whether the head has escaped so as to lie *in front of* or *behind* the plane of this ligament.

The division into posterior and anterior forms includes all cases save those very rare "irregular" ones, where the strong ligaments are torn loose, in which *any* position may be assumed, and those, hardly

* Bigelow, H. J.: "The Mechanism of Dislocation and Fracture of the Hip, with the Reduction of the Dislocations by the Flexion Method," Philadelphia, Henry C. Lea & Co., 1869.

less rare, of "central" luxation, in which fracture of the pelvis at the acetabulum permits the entrance of the femoral head into the cavity of the pelvis* or in which the head is driven through the obturator foramen.

Posterior displacements include the dorsal (including everted dorsal) and the ischiatic type.†

Anterior luxations include the pubic, suprapubic, obturator, and perineal forms.

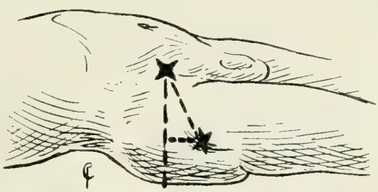


Fig. 712.—Bryant's triangle. With the patient on the back a perpendicular line is drawn from the anterior-superior spine to the table; the perpendicular distance of the trochanter from this line (that is, the length of the short leg of the triangle in the figure) gives the measure of the shortening. This is ordinarily the best single test of shortening.

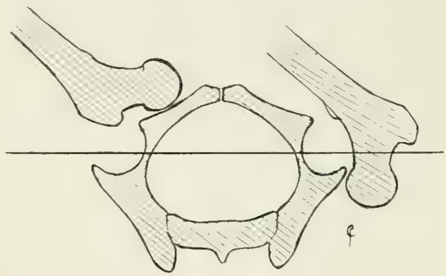


Fig. 713.—Line dividing anterior from posterior dislocations. This line runs through centers of both acetabula.

POSTERIOR DISLOCATIONS

These are far the commoner class. They may occur as a result of falls, but most often as a result of crushing injuries, as in cases where a laborer is caught by a caving bank or is borne down from behind by a falling bale or cask.

The exact mechanism is not always clear, and here, as usually, experiments on the cadaver help but little, for the resisting action of muscles has a definite bearing on the result.

We do know, however, that sharp inward rotation of the partly flexed and adducted leg may be a sufficient cause *alone*, and that a direct *backward thrust* is often the apparent cause.

Allis has ingeniously explained how backward thrust of necessity involves adduction and rotation inward.‡

Probably this scheme holds true for slow-acting forces. It seems probable, however, that a *quick thrust backward*, acting as a *direct thrust only*, may also produce a backward luxation.

* Described under Pelvic Fractures.

† The classic forms of luxation usually described are—dorsal, ischiatic, obturator, pubic, with various subclassifications, and with various forms classed as atypical.

‡ Allis, Oscar A.: "An Inquiry into the Difficulties Encountered in the Reduction of Dislocations of the Hip" (Gross Prize Essay), Philadelphia, 1896 (pp. 85-87).

Ordinarily, the position in which the victim is caught will be found to have been substantially that of Fig. 714. Here adduction inward, rotation, and backward thrust *all act together*.

The important factor in producing rupture of the capsule is *inward rotation*. In inward rotation the head is pried downward and backward against the stretched capsule. Rupture by such forced rotation alone may commonly be produced on the cadaver.

It is probably because the tear in the capsule is constantly so produced by rotation that the situation of the tear at the lower back part of the joint is relatively constant in its site.

Obviously, according to a greater or a less degree of flexion at the time of rupture, the tear will lie a little further forward or a little farther back.

Fig. 714.—Diagram to show how a crushing load may cause flexion, adduction, and inward rotation on the right, with abduction on the left.

When the capsule is once torn, inward rotation tends to displace the head down and backward, while the associated backward thrust in the line of the adducted femur tends to produce backward, or backward and upward, luxation, as the case may be.

After the head of the bone is once out of the socket it may move in various directions around the edge of the socket, according to the proportionate rôle played by the various forces acting.

Moreover, with the head once started toward the dorsum, the mere weight of the leg gives force enough to carry the head (the end of the short arm of the lever, which has its fulcrum in the Y-ligament) farther upward. Any force used in picking up and transporting the patient acts similarly to displace the head further upward.

Therefore, any attempt at *exact* determination of the forces acting to produce the given result is futile. The head, once out, may go in *any* direction.

Certain checks and obstacles (to be considered later) limit the upward progress of the head. Autopsy findings make it pretty clear that in certain cases the head is *driven* through the capsule, or twisted through, in a different way from that described, since they show the site of escape of the head to have occurred *above* and behind. This is not, however, the usual route of escape of the head from the socket.

Lesions.—*Capsule.*—The capsule is ordinarily torn through at the back part at or below the site of insertion of the obturator internus.

The tear varies greatly in length, largely according to the forces acting after the head has left the socket. It varies also in site, being near either the femoral or the acetabular insertion, or running irregularly between them.

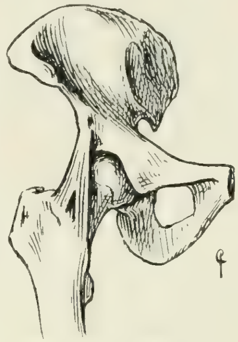


Fig. 715.—Relations of Y-ligament.

Muscles.—The tendons of the small rotators are in close relation to the capsule, and are very apt to be torn with it, as the head goes out or as the upward progress of the head enlarges the capsular tear. Obturator externus, obturator internus, pyriformis, and quadratus muscles (or tendons) have all been found torn frequently; even the gluteus maximus is torn at times. In case of the short muscles they are evidently torn loose by direct pressure of the head, and according to the point of exit any one may be torn, or all may be torn, by the sweep of the femoral head upward, or they may all escape tearing, leaving the head lying behind and below the obturator tendons, or the head may push its way *between* the intact obturator internus and the intact pyriformis, or between the pyriformis and the gluteus minimus, without tearing either.

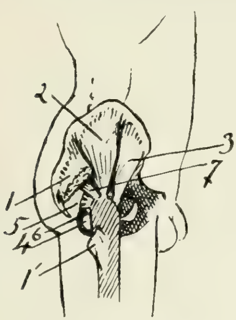


Fig. 716.—Diagram sketch. Relation of muscles to hip-joint: 1–1′, Origin and insertion of gluteus maximus; 2, gluteus medius; 3, gluteus minimus; 4, obturator externus; 5, obturator internus and gemelli; 6, sciatic nerve; 7, pyriformis.

Adductors, pectineus, gracilis, gluteus maximus, etc., may also suffer, but these muscles are probably torn rather by stretching in their length than by direct violence.

Lesions of nerves and vessels are noted later.

Position of the Head.—Posterior dislocations are variously divided: perhaps the conservative classification is as follows:

High dorsal—head up, behind; definitely *on* the dorsum ilii.

Low dorsal—head about between the ischiatic notch and the joint. This is the common type.*

Everted dorsal † (in which the external limb of the Y-ligament is torn); the head lies above the joint and well toward the anterior-superior spine.

Ischiatic Luxation.—(Probably the same as Bigelow's "dorsal below

* The type of luxation called "anterior oblique" is that in which the head lies as in an ordinary dorsal, but the femoral neck has been carried up *across* the acetabulum, and the thigh crosses its fellow in *adduction.*

Bigelow produced this lesion experimentally only: there is no *clinical* evidence of its occurrence, in his time or since.

† There is an especial interest attached to the "everted dorsal" luxation in that the position of the head is about that of the "subspinous" variety of anterior luxation, though the route traversed by the head to reach this position is exactly reversed.

the tendon.") This class takes in cases in which the head lies low and displaced backward in the direction of the ischiatic notch, or further down toward the tuber ischii; these cases are uncommon.

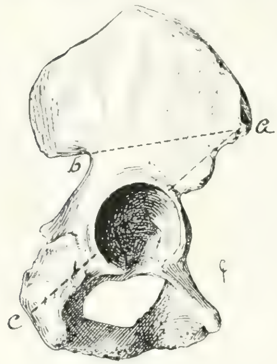


Fig. 717.—Line *a-c* from the anterior-superior spine to the tip of the tuberosity practically bisects the acetabulum and divides anterior from posterior displacements; *i. e.*, any displacement in which the head lies in front of this line must be called anterior and vice versa. The line from the anterior superior spine to the top of the notch (*a-b*) is the limit shown to be rarely passed by any of the posterior displacements, which lie, in fact, much lower than is usually supposed.

It is to the credit of Malgaigne to have shown that dislocations "on the dorsum ilii" hardly ever really reach the dorsum, and that the run of dislocations lie *lower* than we ordinarily think. It is indisputable that the head only rarely passes above a line drawn from the anterior-superior spine to the top of the greater sciatic notch. (See Fig. 717.) The misconception in this regard is perhaps in part due to the fact that the pelvis in standing or lying is tilted: a dislocation *upward* goes toward a part of the pelvis that the anatomists persistently call *backward*, which lies, in fact, *upward and backward.*

Symptoms.—In the typical dorsal dislocations we have flexion and adduction, with apparent shortening of the limb, a shortening in part actual, in part due to the error of measurement in the presence of adduction. (See Fig. 711.)

There is usually sharp inversion—commonly the toes rest on the dorsum of the sound foot. *Inversion* is *greatest* in the luxations of the ischiatic type, *less* in those high up on

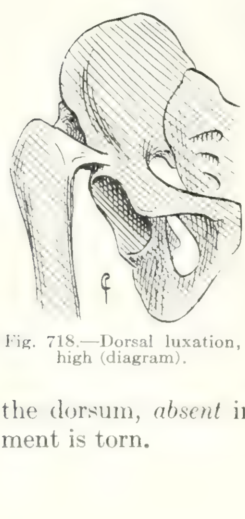


Fig. 718.—Dorsal luxation, high (diagram).

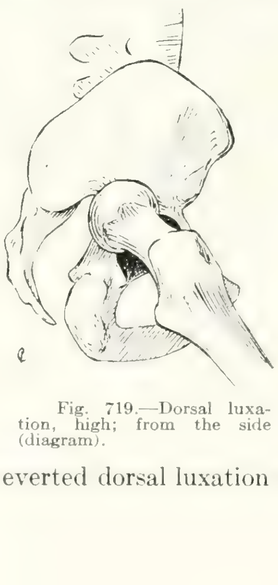


Fig. 719.—Dorsal luxation, high; from the side (diagram).

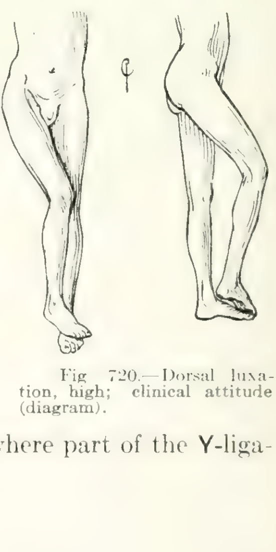


Fig. 720.—Dorsal luxation, high; clinical attitude (diagram).

the dorsum, *absent* in everted dorsal luxation where part of the Y-ligament is torn.

Flexion will obviously be more complete in cases where the head lies low down. The same is true of adduction. There is, however, much variation in position.

Inversion and flexion, at least, do not seem to vary very exactly according to the position of the head. It must be remembered that the tension of the Y-ligament is the main factor in flexion

Fig. 721.—Dorsal luxation, high. Produced on the cadaver by the writer by adduction and forced inversion.

Fig. 722.—Old dorsal dislocation with false socket (Warren Museum, specimen No. 1180).

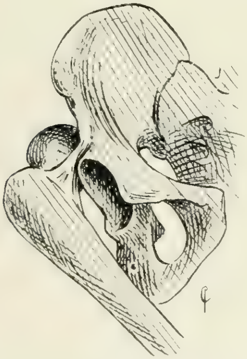


Fig. 723.—Dorsal luxation, median (diagram).

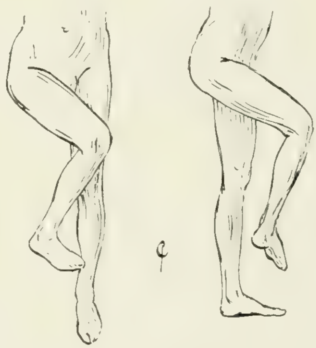


Fig. 724.—Attitude in dorsal dislocation, median

and inversion; this tension is directly proportionate to the distance the head is displaced away from the joint cavity.

The varying obliquity of the planes of ilium and ischium on which the head rests have a bearing on the position of the head and leg, but there would always be inversion, even if the pelvis were flat-sided, because of the tension of ligaments.

Fig. 725. — Dorsal luxation, low, extreme adduction (diagram).

Fig. 726.—Attitude in dorsal dislocation, median (from below).

Fig. 727.—Clinical attitude; dorsal luxation, low (diagram).

As to flexion, the lodgment of the head on the pelvis (with the tension of the Y-ligament) may be the only factor in maintaining flexion —or there may be a resistance of the external rotators, under which the head is hooked. This relation varies not only with the position of the head, but with the point of exit, with the amount of tearing of these muscles, etc.

Fig. 728.—Crayon sketch from the cadaver. Dorsal dislocation produced by circumduction (with very little force) from a thyroid dislocation.

In dorsal luxations the head is not often palpable; in thin persons it may often be felt vaguely; in fat people it is commonly buried out of reach.

The acetabulum is so rarely palpable that it is hardly useful as a landmark.

A patient with dorsal luxation is unable to walk or to stand on the leg.

Shortening is usually obvious, but, in fact, the *anatomic* shortening is slight; most of what we see is the *apparent* shortening of adduction.

The patient stands (if he can stand on the sound leg) with a more or less marked lordosis. If he lies down, this lordosis largely disappears, and the abnormal position of the leg becomes more obvious.

On testing motion we find that extension, abduction, and outward rotation are sharply and definitely checked. Flexion, increase of adduction, and rotation inward are usually practicable. If flexion is also limited, this should mean—and probably does mean—a luxation *above* one or more of the external rotator tendons.

In dorsal displacements there is loss of the prominence of the trochanter and of the hollow behind it; the gluteal fold is higher than normal; the ligaments and the tense muscles prevent palpation of the acetabulum in front.

The head *may* be palpable behind; as a rule, it is not.

There is no filling up of the space just below the groin as there is in hip fractures.

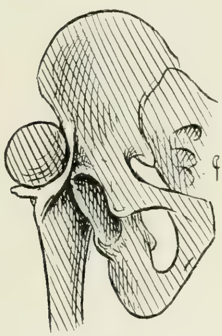


Fig. 729.—Everted dorsal luxation. Note how the Y-ligament, torn in its outer part, has become wrapped under the head of the femur.

Fig. 730.—Everted dorsal luxation. Clinical picture (diagram).

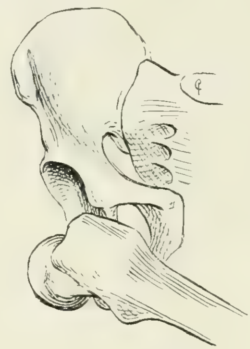


Fig. 731.—Ischiatic luxation (diagram). Substantially on the border-ground between anterior and posterior luxations, though here classified as posterior.

Measurements carefully made show little shortening. *Real* shortening is not over ¾ to 1 inch.

Decrease of distance from the anterior-superior spine to the trochanter is not over 1 inch, and is usually distinctly less.

There need be no question as to the presence of inversion or eversion, inasmuch as the foot necessarily moves with the leg. The relations are often made clearer by flexing the knee.

The rule usually given is that the head points very nearly in the same direction as the internal condyle at the knee. This is true, but the way the *foot* points (at a right angle to the pointing of the condyle) gives a handier check, equally reliable.

We have, then, a tolerably constant picture in almost all dorsal luxations, as shown in Figs. 719–728.

The few exceptions are the "irregular" luxations known as everted dorsal. (See Figs. 729 and 730.)

In *everted dorsal* luxation the femoral head is no longer in contact with the broad surface of the ilium, but has swung clear anteriorly, and the restraint of extension and outward rotation no longer exists; the displacement of the axis of the limb is but slight, and there is a good deal of mobility. There is extreme *out*ward rotation.

The attitude is very similar to that of everted pubic luxation, but the dorsal form will hardly show *so much* eversion. Allis says that in this form direct pressure on the head will cause it to sink, as a "shifted thyroid" will not.

Ischiatic Luxations

Dislocations known as ischiatic are perhaps a transition form between anterior and posterior, but may be described here. They are the rare cases when the head rests just below and behind the acetabulum, on the *ramus* of the ischium. (See Fig. 731.) The rarity of this form is no doubt due to its instability; obviously, only a little force is needed to shift the head either way—displacement posteriorly is almost certain if the patient lies on his back, owing to the weight of the leg. A few clean-cut cases are reported, however, of real ischiatic luxation.

Clinically, this lesion differs from the low dorsal type only in the presence of greater flexion.

ANTERIOR DISLOCATIONS

We have the following types—

Pubic—including *suprapubic* (and infraspinous or subspinous); *reversed thyroid; obturator; perineal.*

Broadly speaking, these are luxations resulting from abduction and extension, rather than from the adduction and flexion responsible for the dorsal types.

The mechanism is not constant, of course, and the ease with which an anterior may be converted into a posterior displacement, and vice versa, should make us cautious in any statement as to the mechanism of production.

The escape of the head in both types may be pretty low down; as a rule, it is definitely further downward and forward in the anterior forms.

The capsule in anterior luxations is torn *below* and in *front;* the encircling rent stops in front at the Y-ligament. The rupture of the capsule in this form of luxation is a result of *direct* strain in abduction—usually in abduction in the "coronal" plane, without flexion.

In this sort of trauma we have a *bony fulcrum* to deal with—that of the neck against the acetabular rim:

Abduction of the leg, with this fulcrum, obviously gives ample pressure below to burst the capsule; and this is usually the mechanism of rupture. Simple *hyperextension* of the hip may cause—and has

caused in indisputable cases reported—a like luxation, with a tear well forward in the capsule. Here the hyperextension gives the force for leverage, while the back of the acetabulum and the Y-ligament give a combined fulcrum, so to speak.

Such a mechanism of displacement is rare; the dislocation by abduction is the rule.

Lesions.—The capsule is torn in front and below. The Y-ligament is usually intact. The ligamentum teres is torn across or is lifted out of its insertion.

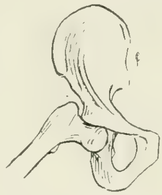


Fig. 732.—Shows how the edge of the acetabulum forms a fulcrum for the neck of the femur by which, in abduction, the head may be *pried* out of the socket.

Muscle damage is exceptional, apparently. Of course, muscles in the direct path of the head may be damaged, though, as a rule, they are not.

The sciatic nerve is not exposed to injury. The anterior crural nerve is so exposed in the *pubic* forms of luxation, and anesthesia, with some muscle atrophy in the area of its supply, temporary or permanent, results in some cases.

Vessel injury is more likely in this form than in the posterior luxations,* but is vastly uncommon.

Obviously, luxation by hyperextension stretches the vessels across the displaced head in dangerous fashion; carried far enough, it must cause vessel rupture almost of necessity. In the common trauma by abduction there is but little chance of this complication, for the head lies on a deeper plane than the vessels.

Fig. 733.—Luxation onto pubes. Clinical attitude. Extension, abduction, external rotation, prominence of the head in the groin (diagram).

Compound luxation is far more apt to occur with anterior luxation than with the posterior, though it is always very rare.

Position of the Head.—The head may lie over the obturator foramen, or, driven to the limit of the length of the ligament, it may go so far inward as to present in the perineum.

Displaced forward, it not uncommonly lies on or just below the pubic ramus; rarely, it passes the ramus and may lie under the Y-ligament, which is stretched across the front of the femoral neck. (See Fig. 736.)

Or, by outward rotation and adduction, the head may come to lie at a point close under the anterior spine; in this case the position is very like that of the everted dorsal form noted above.

* The only two cases of damage to the great vessels of which I find record (Deboué, and one case noted in a report of the fourteenth Prussian army corps, 1878) were both pubic luxations.

Symptoms.—In all cases of anterior luxation the limb is extended more or less fully, in contrast to the posterior forms: extended in more or less marked abduction.

Unlike the dorsal luxations, this anterior dislocation does not absolutely interfere with walking, though such walking must be clumsy and accompanied by much pain.

There are no *fixed* lines or boundaries between classes and subclasses, clinically, in the anterior luxations.

The head escapes under an abducting force at a point so far forward

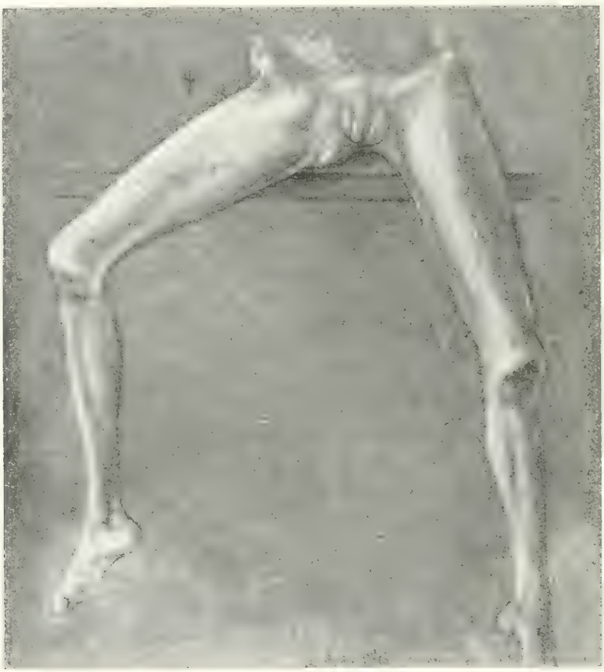


Fig. 734.—Crayon sketch from the cadaver on which a pubic dislocation was produced by manipulation (extension, abduction, outward rotation, and leverage).

that it does not tend to slip up and backward, and we find a displacement forward that carries the head to any point between the ischial ramus and the pubes, or even to a point under the anterior-inferior spine.

All displacements of this sort—whatever they have been called by zealous lexicographers—are in essence the same, and the treatment is the same, save for slight modifications.

For convenience, we divide the displacements into pubic (with its variants) and obturator and perineal types.

Pubic Luxations.—Here we have displacement of the head *up* and *forward.*

Eversion is marked, and cannot be corrected.

There is definite fixed abduction, though this is less than in the obturator and perineal cases. Adduction is impossible. The leg, seen from the side, is in nearly full extension.

There is apparent lengthening.

The prominence of the trochanter fails; the trochanter lies near to, sometimes actually *in*, the acetabulum.

The acetabulum is not palpable, with rarest exceptions.

The head lies beneath or even internal to the vessels, and is palpable—and usually visible—as a fullness in the groin, even if its outlines are not to be made out clearly. The actual position of the head varies; it may—usually—lie below the ramus of the pubes, or it may ride up on it, in which case its presence there is very readily made out.

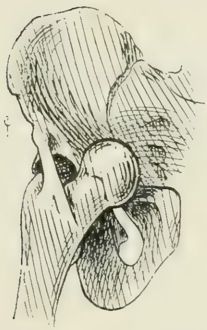


Fig. 735. — Suprapubic luxation showing bones (diagram).

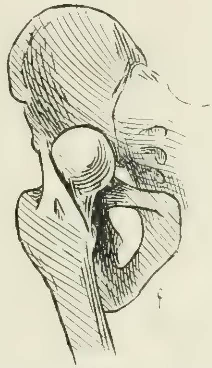


Fig. 736. — Subspinous dislocation. By adduction of the leg, the head has been forced outward, the Y-ligament lying closely applied to the front of the neck.

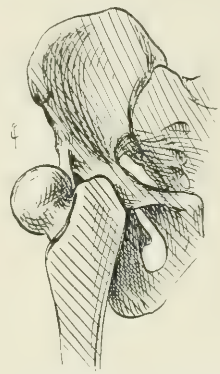


Fig. 737.—Everted anterior (thyroid) luxation. Position of bones (diagram). Compare this and the next figure with Figs. 729 and 730, the everted dorsal type, in which the position is nearly the same, reached by opposite routes of rotation. In the everted thyroid the Y-ligament is wrapped around behind the neck; in the everted dorsal it is wrapped around in front of the neck.

Dislocation of the head *over* the brim of the pelvis implies very extensive capsular damage; it is rare.

The farther the head rides upward, the less will be the permanent abduction, and the greater will be the rotation outward.

Suprapubic Luxation.—If the head passes over the brim, we have the rare suprapubic form. In this case the prominence of the femoral head in the groin can hardly leave a doubt as to the diagnosis. In place of slight flexion of other anterior forms we have a position of full extension. Abduction is slight.

Infraspinous or Subspinous Luxation.—This is a form in which

adduction has forced the femoral head to a point close to the anterior-superior spine, where it is firmly held by the Y-ligament, under which the neck has been forced. (See Fig. 736.) There is no permanent abduction; no flexion; there must be definite outward rotation.

Fig. 738.—Everted anterior luxation. Clinical attitude (diagram).

Fig. 739.—Obturator luxation (diagram).

Fig. 740.—Obturator luxation. Clinical attitude (diagram).

Everted Anterior Luxation (*Reversed or Everted Thyroid*).—In the cases known as reversed thyroid, the head has come to a position where it is hooked over the Y-ligament; there is no longer any firm fulcrum, nor

Fig. 741.—Obturator luxation. Clinical attitude from below (diagram).

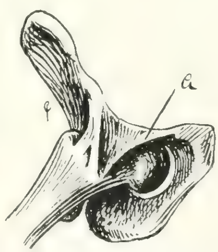


Fig. 742.—Obturator luxation. Relation of head to ligaments. Internal branch of Y-ligament alone is taut. Outer branch of Y and pubo-femoral ligament (a) are both slack,

Fig. 743.—Luxation into the perineum. Position of bones (diagram).

any ligamentous resistance to maintain abduction, but the external rotation is extreme. (See Fig. 737.) The position is like that of the everted dorsal, but the eversion is greater, and there is the possibility of abduction to a greater extent than in the dorsal form. The pro-

duction of this form of displacement is by excessive outward rotation from the pubic or suprapubic form. (Compare Fig. 729, "everted dorsal.")

Obturator Luxation.—In obturator luxations we have some flexion,* abduction, and rotation outward. Measurements show an apparent lengthening, but this is due, in the main, to the error of measurement, unavoidable where there is any abduction, rather than to real displacement. Flexion, properly speaking, is not present in any considerable degree; *lateral* flexion of the everted leg should be described not as flexion, but as abduction.

Fig. 744.—Luxation into the perineum. Clinical attitude (diagram).

The head of the femur is not ordinarily palpable, though some fulness may indicate its position. The empty acetabulum, as a rule, is so covered by muscles and by the tense fascia lata that it cannot be made out. The prominence of the trochanter is lost; sometimes the trochanter is not palpable at all.

Fig. 745.—Central luxation of femur. The head is driven directly inward, substantially, without abduction or adduction, flexion or abnormal rotation in the cases I have seen or found accounts of. Clinically, there is some loss of motion, and loss of prominence of trochanter; sometimes, a little shortening.

Motion is practically nil. Adduction and internal rotation are entirely impossible.

Perineal Luxations.—Perineal luxations show like signs, save that abduction is more marked.

The diagnostic sign is the presence of the head, clearly palpable or felt as a marked resistance, in the perineum.

The position is that shown in Fig. 744.

CENTRAL LUXATION

This name is given to cases in which the femoral head is driven inward into the pelvis. In most cases the head goes through the smashed acetabulum, and penetration is only partial. These cases show no constant deformity save loss of the prominence of the trochanter, and slight—and inconstant—malposition of the limb. There is a little shortening.

The detail of these cases is considered under Pelvic Fracture.

A few cases are recorded in which the femur has penetrated through the obturator foramen, an exaggerated obturator form, so to speak. The deformity is approximately that of the obturator luxation. The

* Allis explains this flexion by the impinging of the *trochanter* on the edge of the acetabulum.

head may be palpable by rectal examination. Reduction is by direct traction and leverage; in these cases the ligaments are gone, and need not be considered.

REDUCTIONS

Inasmuch as the reduction of all typical dislocations (whatever may be the precise position of the head) depends on certain broad principles, it will be well to consider, first of all, the general conditions underlying the reduction problem.

The old-time methods of reduction all aimed at *direct* reduction. All luxations were reduced (or equally often not reduced) by traction carried out with the intention of dragging the head from its false position *to and into* the acetabulum *in a direct line*. In this laudable effort our predecessors seem to have used a degree of force, exerted through blocks and tackle, hardly paralleled except in the most modern "bloodless" surgery.

Such methods succeeded either by accident or by rupture of ligaments. The trouble with such methods is the *excentric* arrangement of the hip-joint. The joint has its point of rotation at a (Fig. 746), its line of weight-bearing or of traction, as the case may be, in the line b–c, and its strongest ligament running from d to e. If the hip is dislocated backward, the relations are about as shown in Fig. 747. If the dislocation is forward, Fig. 748 shows the conditions present.

Obviously, traction in the line b c is not going to give reduction in either case, unless something gives way.

Obviously, it is worth while to modify reduction efforts so that the Y-ligament (d–e) need not be ruptured.

The recognition of the necessity of considering this ligament far antedates Bigelow, but it was Bigelow who first clearly brought out the dependence of all (empirically) successful methods of reduction by "circumduction" on the relations of this ligament, and he showed that by using the ligament as a fulcrum, reduction might be accomplished with a minimum of force and damage.

More recently, Allis, of Philadelphia,* has worked out fresh details and has devised curiously simple and effective manœuvers of reduction, which have been amply proved in practice. Allis pointed out also that sweeping circumduction movements, even when effective enough in reduction, involve unnecessary damage to the soft parts, avoidable by more careful manipulations.

For our consideration today the practical methods are first those of Allis; if these fail, the circumduction methods of Bigelow are to be tried; the older methods, involving greater force, seem to us now far worse than reduction by open incision, which is the modern last resort in late or otherwise desperate cases.

* Allis: *Loc. cit.*

The key to reduction is the "Y-ligament"—the iliofemoral ligament. It is merely a stronger part of the capsule, but a part almost always intact after dislocation, and most important through its strength and its location. It runs from the anterior-inferior spine of the ilium down to the anterior intertrochanteric line. (See Fig. 715.) Ordinarily, it may be considered in practice as a single band; anatomically, its insertion is very broad, and may be considered perhaps as a bifid insertion.

In normal conditions the ligament limits hyperextension and out-

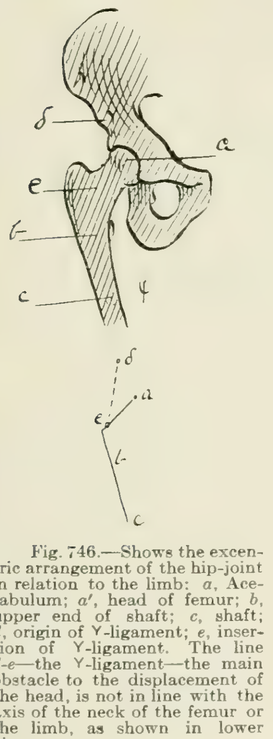


Fig. 746.—Shows the excentric arrangement of the hip-joint in relation to the limb: *a*, Acetabulum; *a′*, head of femur; *b*, upper end of shaft; *c*, shaft; *d*, origin of Y-ligament; *e*, insertion of Y-ligament. The line *d-e*—the Y-ligament—the main obstacle to the displacement of the head, is not in line with the axis of the neck of the femur or the limb, as shown in lower diagram.

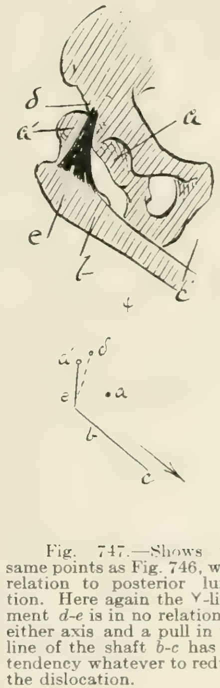


Fig. 747.—Shows the same points as Fig. 746, with relation to posterior luxation. Here again the Y-ligament *d-e* is in no relation to either axis and a pull in the line of the shaft *b-c* has no tendency whatever to reduce the dislocation.

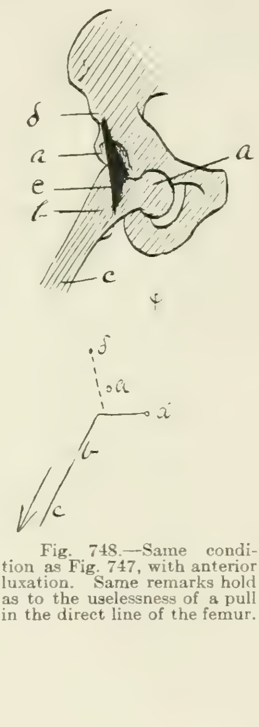


Fig. 748.—Same condition as Fig. 747, with anterior luxation. Same remarks hold as to the uselessness of a pull in the direct line of the femur.

ward rotation. In luxations it becomes the shortest bond between pelvis and femur; it limits motion and determines the characteristic positions of abduction and adduction and of rotation in or outward.

In the posterior luxations it is drawn tense *before* the head jumps out of the socket, and its tension determines the range of adduction, of flexion, and of inward rotation.

In the anterior cases this ligament plays little or no part in the mechanism of production of luxation, but the bony pelvis and the ligament are the fixed points of support afterward, and their relations

determine the abduction and the rotation outward. (See diagram, Fig. 748.)

Let us take first the *posterior* luxation—the head has slipped out below and behind; the head has moved backward; the Y-ligament, not to be stretched, holds the femoral neck close in; flexion, adduction, and inward rotation are necessary consequences.

Extension is impossible because of the resistance of untorn muscles above in the path of the head. Abduction is impossible because the head is fixed at a point well behind that to which the restraining Y-ligament is attached; external rotation also would require stretching of the ligament, already drawn tense by the backward movement, and the ligament will not stretch.

If the displacement is *anterior*, the ligament is also put on the stretch, but the firm support of the head is on the lower and front part of the pelvis; hence there is *abduction*, and adduction is impossible; the head usually lies forward of the line of pull of the ligament, hence there is little or no flexion; and as the head is carried forward and farther forward on the oblique plane of the obturator fascia, or even onto the pubes, the base of the neck can move but little, therefore external rotation must result. (See Fig. 739.)

The manœuvers for reductions based on these data* are, when reduced to simplest terms, about as follows:

FOR POSTERIOR LUXATIONS (DORSAL, HIGH OR LOW)

Gravity Method.—Reduction of dorsal dislocation may at times be accomplished by the simple weight of the limb. The patient is placed on a frame—face down—and the leg and thigh are left to hang down; there is to be no support except at the ankle. Favoring this reduction we may apply pressure to the leg just *below* the bent knee, and may help with rocking rotations of the leg. Reduction, if it occurs, is not immediate, but occurs after muscle relaxation. Obviously, if it succeeds, this is the least forcible and most desirable method.

"Direct" Method (Allis).—1. Flex, using some traction downward and forward. (The head moves down to a point not far from its point of exit.)

2. Lift; if this lift does not produce reduction, then rotate inward to relax the capsule. Now the head may be brought forward, but if it strikes any resistance, this resistance (hamstring tendons or sciatic nerve) may best be avoided by *outward* rotation. It is most important not to use much force. After the movements of rotation to clear obstacles, we must *lift* again.

* Those interested in the history of the development of methods, particularly the neglected work of Physick, N. Smith, Reid of Rochester, and Gunn, of Chicago (all antedating Bigelow) are referred to the interesting chapter in Hamilton, "Fractures and Dislocations," third edition, pp. 634 ff.

3. Extend. Extension may not be necessary. If necessary, it should be done gently, and not forced against definite resistance.

If the head does not pass into place without great force, it is best to go through the reduction again from the beginning, rather than use great force.

As a rule, the head passes suddenly to its place under manipulation No. 3, if not before.

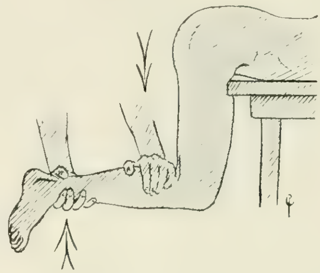


Fig. 749.—Reduction by gravity and slight downward thrust in popliteal space; the simplest method of reduction of the posterior type.

In case we have to deal with a dorsal luxation of the uncommon type, where we have not only a high situation of the head, but a high tear in the capsule and a protrusion of the head high up, just above or below the pyriformis, we must modify the manipulation in so far as we must flex the leg less; the lifting is to be, not vertical, but more nearly in the line of the body.

The especial advantage of Allis's method is that it is relatively free from danger if carefully applied. No great force is admissible, and the temptation to use too much force is far less than with the sweeping

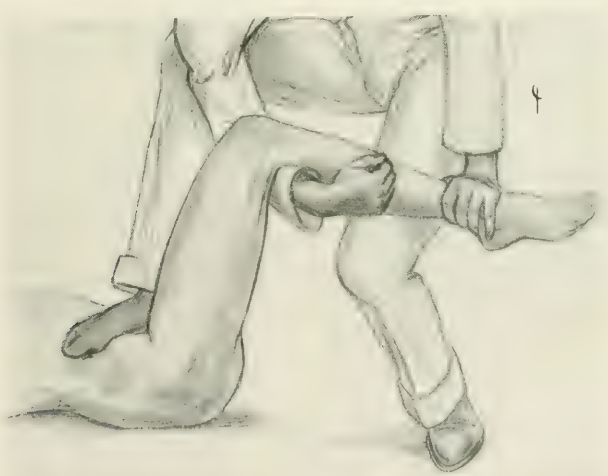


Fig. 750.—Allis's reduction for dorsal dislocation. Flex, lift, rotate in and out, lift again.

circumduction motions. There is no objection to fixation of the pelvis by the unshod heel of the operator or by strapping the pelvis to the table. (See Fig. 752.) Some fixation by the hands of assistants is indispensable unless straps are used.

Circumduction Method (**Bigelow**).—1. Flex (relaxing the Y-ligament).

2. Rotate inward (starting the head downward behind the acetabulum, and clearing it of torn muscles, etc.).

3. Adduct (still further relaxing tissues).

Fig. 751.—Lift; rotate inward; rotate outward strongly and lift. The rotation manœuvers in this reduction are varied to meet the exigencies of the case. Forced rotation in either direction is not usually necessary. (Allis's reduction.)

4. Abduct.

5. Rotate outward (bringing the head down close under the tear in the capsule, and *to* the edge of the acetabulum).

6. Extend (thus prying the head into place, using the Y-ligament as a fulcrum). (See Fig. 754.)

Fig. 752.—Bands to strap pelvis to table to facilitate reduction (according to Allis).

With a bit of practice these motions can all be merged into one continuous rotatory sweep—a real circumduction. It is as pretty as the "tour de maître" with the urethral sound, and open to the same objections of possibility of damage, not only to muscles, but particularly to the sciatic nerve. When it works smoothly, there is nothing to be said against it, but it must always be used with a good deal of caution.

The three methods noted cover the procedures for dorsal luxations.

Here and there there are cases of high luxation in which the head has originally escaped from the joint either above or just below the pyriformis. Such cases are rare.

In very high dorsal luxations (with probable high point of exit) the direct method carried out with less than the usual flexion and more drag down and forward, is in order.

In case of "everted dorsal" luxation we must convert the displacement to the inverted dorsal (high) and then must proceed in the usual way.

This conversion is effected by flexion and adduction, combined with inversion.

High luxation may become "everted dorsal" in type. In case of

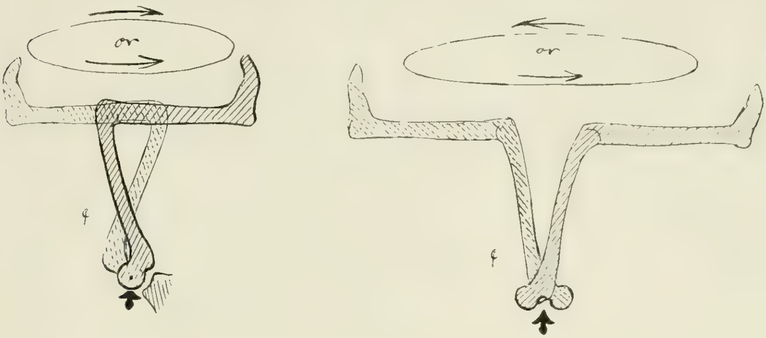


Fig. 753.—Rotation versus circumduction. The sketch on the left shows a rotation movement on the axis of the femur. Such a movement, carried out without moving the knee much from its place, will occur substantially on the head of the femur as an axis. A circumduction movement, on the other hand (see sketch to right), in which the knee is moved widely, occurs about the Y-ligament as a fulcrum, about which the head of the femur describes a smaller circle, corresponding to the motion at the knee.

Fig. 754.—Bigelow's reduction of dorsal dislocation by circumduction. Beginning at lower left-hand corner; flexion, rotation inward, adduction (with increased flexion), abduction, sharp outward rotation, extension. Properly carried out, these motions form a single sweep; reduction occurs ordinarily just at the beginning of extension.

difficulty in the usual manœuvers after conversion from everted to inverted luxation, this point must be borne in mind, and the reduction

may be modified as is outlined for the high luxations. In such cases downward traction is obviously essential to replacement.

In other cases, through extensive rupture of the external rotator muscles, an everted dorsal dislocation may be produced out of an ordinary dorsal displacement.

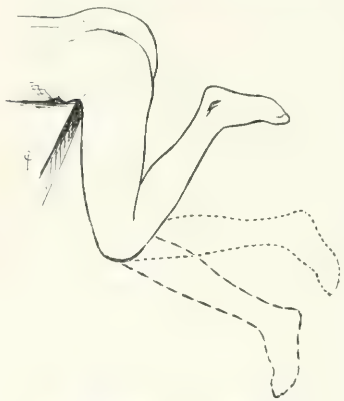


Fig. 755 Test of reduction - according to Allis, with the limb in the position shown if the foot is dropped it will go to the position of the heavy dotted line, but, owing to the elasticity of the hamstring muscles, will rebound for an instant to the light dotted line. This elasticity does not so act unless the head of the bone is in place.

In either case inward rotation, facilitated by moderate flexion and adduction, will produce a dorsal *inverted*.

In the apparently similar anterior *subspinous* forms, such an inversion manœuver meets impracticable resistance.

In case of dorsal luxations presenting difficulty of reduction it has been recommended that the tear in the capsule and the gap in the rotator muscle group be increased, in order to facilitate replacement through an enlarged opening. The method of procedure to enlarge the tear in the capsule is by flexion, adduction, and forced extension. This seems to have been a successful manœuver in some cases, a manœuver justified in rare instances, but not lightly to be undertaken without considering that muscles and capsule are to be torn, and that the sciatic nerve may be injured.

Reduction of Anterior Luxations

In anterior displacements we have a problem essentially different, and this difference brings us back again to the Y-ligament. In dorsal luxations we have a relation roughly corresponding to Fig. 747, with the Y-ligament free as a "strap" fulcrum. In anterior luxations this ligament lies *across* the neck, and in pubic luxations it lies closely applied to the neck (see Figs. 735 and 736), and in the cases with extreme eversion, the ligament is wound about the neck. (See Fig. 737.)

Moreover, we are here dealing with a class of luxations in which a bony fulcrum is decidedly an element in the act of luxation, but cannot be used in reduction. This fulcrum is the upper edge of the acetabulum, with which the neck comes in contact in extreme abduction. In luxation, head and neck move inward to a point where no bony fulcrum is available in reduction.

Obviously, the simplest reduction is to bring the head opposite the tear in the capsule through which it has been pried out, and then to thrust or pull it back.

Allis's scheme of reduction aims at just this. His manœuver is as follows:

Allis's Reduction.—Abduct the leg sharply in slight flexion. Let an assistant *fix* the head with his fingers.

Exert moderate traction in the line of the femur.

Adduct.

(Figs. 756, 757, 758.)

This is really a reduction by leverage. The leg is the lever, the fingers the fulcrum, and the head, already brought opposite its place of exit, is pried gently into place.

Fig. 756.

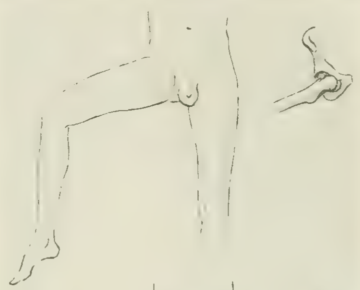


Fig. 757.

Fig. 758.

Fig. 756.—Anterior luxation.

Fig. 757.—Reduction of same; first manœuver according to Allis. Traction in the line of the abducted femur; pressure outward and backward on the prominent head of the femur exerted by the two clenched hands.

Fig. 758.—Second manœuver of reduction; the leg is adducted, the pressure of the fists over the femoral head giving a fulcrum. The leverage so obtained, plus the direct thrust of the head toward the acetabulum, accomplishes the reduction.

If this scheme does not work, we may try the "indirect" method by circumduction, with rotation *in* or *out*, the method in which the Y-ligament is used as a fulcrum to "cram" the femoral head into place, methods associated with Bigelow.

Reduction by Inward Rotation.—Flex the thigh, but not to a perpendicular.

Abduct (with traction downward).

Adduct.

Rotate sharply inward.

Carry down into extension. (See Figs. 760, 761.)

In this method the Y-ligament is the fulcrum, and the head, carried down and outward in the abduction and adduction movements, is pried into place by rotation and extension.

The great drawback to this method is that anterior are very apt to be converted into posterior luxations, with increased laceration of the capsule. This may, in a measure, be guarded against by a lift just prior to extending.

It is purely a question of whether the head, as it is swept around below the joint, finds an easier path backward into the joint or into the hollow

beneath; in other words, whether it jumps the lower acetabular edge or not. If it does, well and good; if not, we have a backward luxation, reducible enough, but already associated with a good deal of damage to the soft parts.

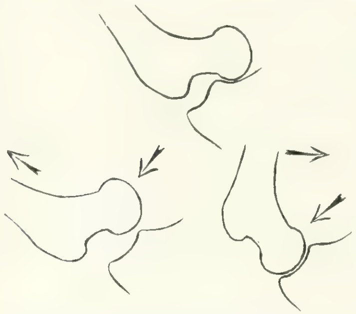


Fig. 759.—Upper figure shows anterior dislocation seen from *above*. The lower figures show Allis's reduction. The figure to the left: Traction in the line of the abducted femur, with pressure outward and backward on the femoral head (see arrows). To the right is shown the adduction which, with continued pressure on the head in the same direction, accomplishes the reduction.

Reduction by Outward Rotation.—1. Flex the thigh, but not to a perpendicular.

2. Adduct.

3. Carry knee *down* and inward.

4. Rotate *out*ward. (See Fig. 762.)

Flexion relaxes the Y-ligament, especially the inner limb, and moves the head closer to its point of escape.

Adduction brings, or should bring, the head close to the rent in the capsule.

Rotation outward (the thigh still flexed) pries the head into place, the Y-ligament acting as a fulcrum.

Slight traction forward (upward as the patient lies on his back) will help the head into place.

It is very important in this, as in other methods, to avoid any pressure backward in the line of the axis of the bone. Hence the rule never to place the hand on the knee in front.

In this and in the preceding method *too much* flexion drives the head toward the thyroid foramen.

The obstacle to this reduction by *outward rotation* is the Y-ligament, or rather its internal limb. Either insufficient flexion combined with the adduction, or outward rotation begun before the head has moved under this ligamentous band, may bring the head up against the ligament, *or up and over it in front.*

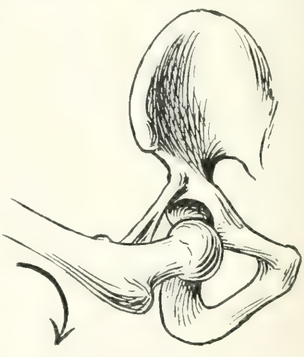


Fig. 760.—Reduction of anterior dislocation by internal rotation (bone diagram). If the bone in the position shown is rotated inward and slightly extended, it is evident that it must do one of two things—either slip into the joint underneath the Y-ligament or slip around back of it behind the ligament.

If the reduction seems to require force, we should begin again with more flexion, and with rotation attempted only after adduction is complete. In this, as with all the circumductions, the reduction goes better if all movements are combined in a given *tempo* in one sweep, but this is possible only with some little practice. This method, by rotation outward, seems to have a better record clinically than the

apparently more rational method by rotation inward, and is free from the risk of converting an anterior into a posterior luxation.

Other Methods of Reduction.—Other methods seem hardly worth mention in regard to reduction of the usual forms of luxation forward,

Fig. 761.—Anterior dislocation; reduction by inward rotation (Bigelow): 1, Flex but not to a perpendicular; 2, abduct and flex; 3, adduct in flexion; 4, rotate sharply inward; 5, carry limb downward into extension.

save that *irregular rocking* and slight *rotatory* motions under traction may materially assist the result in all the methods above described.

Something perhaps may be said for the old method of traction and

Fig. 762.—Anterior luxation; reduction by outward rotation: 1, Flex, not to perpendicular; 2, adduct; 3, carry knee slightly down and inward, and reverse rotation, rotating outward; 4, at the same time extending the leg.

adduction against countertraction, and across a fulcrum represented either by the operator's foot in the groin, or by a sling similarly placed held by an assistant. (See Fig. 763.) In both modes remember that traction in abduction must *precede* adduction. I know of no reason

against the employment of this method where other methods chance not to work. The method has some record of successful employment.

In case the head rests *on* the pubes, we must first fetch it clear of bony obstacles by downward traction and abduction, then proceed as above described.

Suprapubic Luxation.—If the head lies *over* the pubic brim, traction in moderate abduction *without* flexion will bring it down. Until it so comes down, flexion, abduction, direct traction, etc., are of no avail, and may do harm.

Reversed Thyroid.—In case we have to deal with an extreme *everted*

Fig. 763.—In case a stronger lift is desired, the operator's bare foot may be put in the groin or over the pubes, thereby greatly increasing the force applied without changing the method of reduction.

displacement, the head must be brought back, by careful internal rotation with very slight flexion and under traction, to the usual position of a suprapubic, then of a pubic luxation; the reduction is then completed as in an ordinary pubic luxation.

Obturator Luxation.—The reduction is essentially the same as with the pubic, save that in the direct method traction is to be employed in *more marked abduction*, and abduction is to be made more marked than already exists in order to clear the jammed head; some increase of existing external rotation is likely to help toward the same purpose.

According to Allis, in *all* cases of anterior displacement at the instant the head left the socket the shaft was in abduction at right angles to the trunk; hence he recommends traction in this line, accompanied by rocking motions, to retrace the last step in the displacement.

Certainly in the thyroid cases this is wise advice.

Perineal Luxation.—This is an exaggerated form of thyroid luxation; for its reduction the first thing needful is to reduce it to the thyroid form. This is to be done by traction *outward* with the leg at a right angle (or more) with the body. This traction in the axis of the leg may be combined with gentle rotatory and rocking movements. Once the head starts outward, we have only a thyroid luxation, to be dealt with as usual.

LUXATION WITH FRACTURE OF THE FEMUR

The difficulty in diagnosis is not to ascertain the presence of the fracture, but to be sure of the dislocation—unless the fracture occurred in attempted reduction.

The only signs available will be those of the direct recognition of landmarks, the presence of mobility and crepitus, and the evidence of the skiagraph.

I think it fair today to throw aside all the older procedures; I have not had to meet the condition, but should not hesitate to cut down on the upper fragment, to drill a hole in it, insert a hook, and try to reduce, as is done in fracture luxation at the shoulder. Failing in this, I should feel that an open arthrotomy was justifiable.

It is true that some cases have been reduced by the routine methods without incision (in anterior luxations always, I think),* and one would perhaps be wise to try this first.

COMPOUND LUXATION AT THE HIP

Such cases are very rare. Cheever† lists eight cases. Of these, four were of the pubic type, two obturator, one dorsal, one ischiatic. Of these eight, six died either from associated injuries or from sepsis following reduction, or, more often, after excision of the head and replacement of the stump of the femoral neck. Many of these cases antedated any real understanding of asepsis.

Probably today, in a period in which our methods should insure at least a relative asepsis, we should do less excisions and more reductions with disinfection and with all antiseptic precautions. Time alone can

* Dr. G. H. Monks, of Boston, recently reduced a case of anterior luxation (suprapubic) with a fracture just below the trochanters, using traction and pressure, much as in Allis's reduction scheme.

† Cheever: Boston Med. and Surg. Jour., 1891, cxxiv, 523.

tell whether results will be different, but I trust the years to come will show a less melancholy total in these cases.

Fig. 764.—Compound anterior dislocation of the femur (drawn by the writer by the kind permission of Dr. David W. Cheever, from his original photograph). Note the extreme outward rotation shown by the position of the knee and lower leg, as well as by the position of the extruded head. The nipple-like projection on the head of the bone is the torn and retracted ligamentum teres.

OLD DISLOCATIONS OF THE HIP

Reduction of old dislocation has been reported in several cases as late as six months after the injury, accomplished by usual methods of manipulation.* Today we would be apt to consider open operation rather than to take the ever-present risk of breaking the femur or doing other serious damage in the forcible manipulations unavoidable in such reductions.

AFTER-TREATMENT

In the ordinary run of cases a reduced hip luxation is not apt to recur. Fixation by sand-bags or by tying the knees together is ordinarily sufficient, and need be continued only for two or three weeks. In a very few cases there is a tendency to reluxation. These are supposed to be cases in which the acetabulum has been broken in such fashion that its rim no longer furnishes an obstacle to luxation.

While this seems to be an assumption, it is probably correct in some cases. (See also Fracture of Head of Femur, p. 454.)

Whether acetabular fracture is the cause or not, certainly any luxation that tends to recur calls for care, and particularly for long fixation for repair of bony and fibrous tissues.

The ordinary luxation admits of weight-bearing, beginning at three

* Hamilton: "Fractures and Dislocations," third edition, p. 679.

weeks;* a luxation that tends to recur would hardly be safe to trust under eight weeks.

It goes without saying that a luxation with fracture must be subjected to the fixation and other after-treatment suited to the fracture, usually much longer than any luxation would call for.

PROGNOSIS

Reduced hip luxations leave little disability usually. Any tendency to reluxation is very rare.†

There seems to be little or no trouble from the muscle-tearing that often occurs.

Some weakness commonly persists for some time.

Traumatic arthritis may result, especially if reduction has been long delayed. To this complication older patients are more liable than the younger.

Even in unreduced dislocation the functional result is apt to be very tolerable. Some part of the restriction of movement disappears with time; a new hip-socket develops, and the patient is at least able to walk after a fashion, and obtains a better result than is seen, for instance, with ununited hip fracture.

OBSTACLES TO REDUCTION

There is no blinking the fact that reduction of a dislocation at the hip often presents difficulties. In the old days such failure was apparently very common. Today, even under the best methods, in the hands of skilled operators, such failure is by no means unknown. What are the causes of failure?

It is of no use for us to consider the causes of failure under obsolete methods of treatment; for us, the question is of the obstacles that present themselves to those practising modern methods.

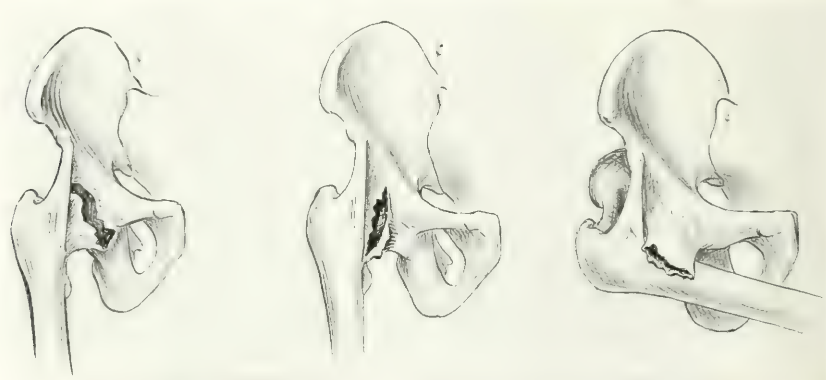
The Capsule as an Obstacle.—The capsule may be torn near its origin from the pelvis, or near its femoral insertion. It is not likely to offer any resistance, save in the cases where the tear is small and our efforts to bring the head to the point of exit are not very successful, or where much of the circumference of the capsule has been torn far away from the acetabulum, leaving a sort of cuff of some length. This condition has been reported in several autopsies.

* After reduction, there is no *mechanical* reason why any hip that has been dislocated cannot bear weight. The period of rest prescribed is essentially precautionary, a time given the capsule and other damaged structures for repair.

† In "Surgical Observations with Cases and Operations" (J. Mason Warren, Tichnor & Fields, 1867, p. 365, case ccxv) is described an interesting case of the sort, cured by proper immobilization after frequent recurrences.

In case of failure by other methods, in the first case, we may try "carrying the head of the bone toward the opposite side of the socket, and thus enlarging the slit" (Bigelow). This will not help but rather hinder in the case of an obstructing cuff. Allis has had good luck, experimentally, in this type of obstruction by rotating the leg and dragging it forward as it hangs over the edge of a table—the body being in the prone position.

Unfortunately, there is no way to differentiate between the forms of capsular obstruction clinically. All we know is that there is an obstacle to reduction or to free motion after an apparently complete reduction; there may be a tendency to recurrence of luxation. Looping up of the sciatic nerve may be definitely excluded, but there may be either muscle or capsule in the way, and we cannot tell which.



a *b* *c*

Fig. 765.—Three types of rupture of the capsule: *a*, Close to the acetabulum; *b*, across the middle of the capsule; *c*, close to the insertion; this last may give at times a lax, sleeve-like capsule, into which reduction is very difficult.

If the obstacle is a direct obstacle to reduction, a resort to the reduction in prone position may be wise, or we may have to enlarge the rent, risking any damage.

If the head is in the joint, but does not move freely, we should try the method of "cleaning the socket" proposed by Allis. (See Fig. 767.)

As to the clinical success of these manœuvers, nothing definite can be said, for the diagnosis is never certain. On the cadaver, they work.

Muscles.—The important relation of intact muscles to possible difficulty of reduction is in the high luxations. We may have the head emerging just below the pyriformis or just above it. Obviously, in such case we must depend rather on traction than on circumduction in the first motion of our attempts to reduce. Any forcible attempt at reduction on typical lines can result only in unnecessary tearing of muscles.

It is alleged that muscles—torn muscles—may constitute a direct obstacle to reduction, in that muscle fragments, especially of the obturator externus, may fill up the acetabulum or obstruct the way into it. Probably this is true. In case of a reduction, apparently successful except that complete extension is not practicable, we may assume, if sure that the sciatic nerve is clear, that muscle or capsule interposition is the cause. If this is so, no course is open to us save repeated move-

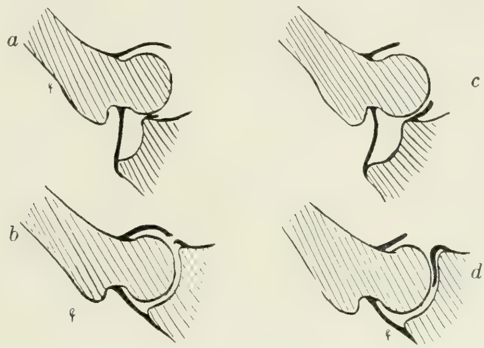


Fig. 766.—If the tear in the capsule in front is close to the acetabulum, *a*, the capsule will probably preserve its normal relations during reduction, *b*; if, on the other hand, the tear is some distance from the acetabular edge, *c*, a fold of the capsule is very likely to be carried in with the joint in reduction, *d*.

ment of *rotation* directed toward destruction of such muscle portions,* and the manœuver directed to cleaning out the socket of capsular fragments. I suspect this condition is rare, clinically, though common in cadaver experiment.

Tearing of the longer muscles, adductors, gracilis, glutei, etc., offers no obstacle to reduction.

Fig. 767.—Shows how fragments of the capsule caught in the joint can be cleared out by the action of the joint-head by repeated motions of abduction and adduction.

Sciatic Nerve.—In posterior luxations we may have the sciatic nerve—

(*a*) Merely bruised in luxation or in reduction.
(*b*) Caught up in the luxation.
(*c*) Caught up in reduction.

*In itself muscle tearing seems not to be very important. So far as I know, no connection has been traced between such muscle-tearing and any later disability. Muscle tears in general do, in fact, heal with some disability, and probably this rough rule works in muscle tears from hip luxation, as well as elsewhere.

If the nerve is involved in the luxation primarily, it is not an obstacle to reduction, but is a serious complication until reduction has relieved the nerve tension. The position is that of Fig. 768. Between this lesion and mere bruising of the nerve we have no reliable diagnostic points, though the *continued* stretching must in the end give more pain and more functional damage than simple contusion.

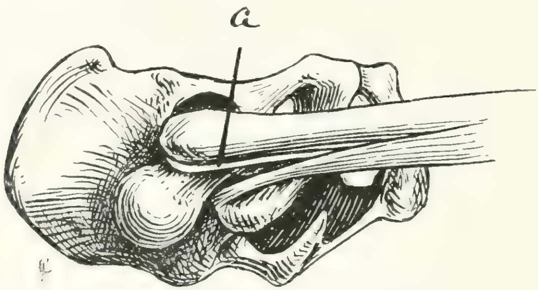


Fig. 768.—Shows how the sciatic nerve may be caught up over the head of the bone in a dorsal luxation. The head of the bone has been driven between the nerve, (*a*), and the biceps tendon, with which the nerve is in close contact at this level.

The nerve may be caught up as the femur is displaced, either in direct backward luxation, or in cases where backward displacement is secondary to an escape originally forward. The mechanism is a picking up of the nerve by the head as it moves back and out. The nerve has been found ruptured; it may, however, lie across the back of the neck

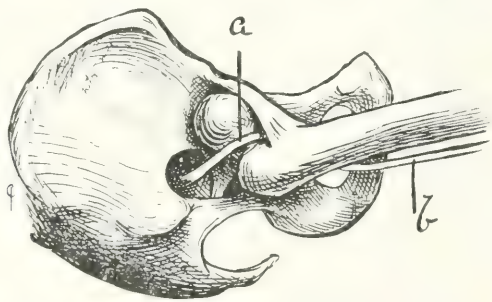


Fig. 769.—Shows how the nerve may be caught up not in the luxation, but in the reduction. The nerve (*a-b*) is caught up over the front of the femoral neck. This condition may not only result in severe nerve damage, but prevents complete extension in reduction on account of the actual shortening of the nerve.

without having been very seriously damaged. No signs beyond those belonging to damage to the nerve itself would be present. Such an entanglement would almost necessarily be reduced by the flexion involved in any proper attempts at reduction.

In the anterior luxation the nerve is not exposed to trauma.

The sciatic nerve may be caught up in attempts at reduction of posterior dislocations.

The nerve is most apt to be caught up in *circumduction* movements. It lies close to the origin of the hamstring tendons, and somewhat tied to them by areolar tissue, and is nearly in the path of the head as it is moved in circumduction. If the first trauma has separated its loose attachments, it may very readily be picked up by the moving head and carried in front of it. At the completion of reduction it will then lie stretched across the femoral neck in front (Fig. 769).

If this accident happens, we have two signs of it:

First: The tension of the nerve prevents complete extension; but this sign is also common, though in less degree, to the interposition of capsule or of muscle.

Second: There will be a tendency to flexion of the knee, and on attempts at extension of both hip and knee the sciatic nerve may be felt as a tense cord in the popliteal space. This can mean nothing else but a looping-up of the nerve.

Obviously, redislocation is indispensable. After the head is again out of the socket, inward rotation (carried to the extreme) will *free* the nerve, and flexing the knee will render it slack, but this does not replace it. We must try abduction and adduction and rotation (avoiding flexion), and then reduce the luxation without flexion. If, even so, we cannot reduce the luxation without catching the nerve, Allis's suggestion seems practicable and certainly justifiable—namely, to redislocate and then cut down on the nerve in the popliteal space, and draw it tense over the finger while the dislocation is again reduced. I do not know that this has been tested clinically. If it should fail, our only resource would be arthrotomy and open reduction,—a serious operation,—but far preferable to the prospect of permanent flexion with inevitable degeneration of the nerve and paralysis or paresis of the muscles it supplies.

CHAPTER XXIII

HIP FRACTURES

Hip fractures are clinically divisible into—

(1) Fractures of the head.

(2) Fractures of the neck.

(3) Separation of the epiphysis.

(4) Fracture of the *base* of the neck.

(5) Fractures through the trochanteric region.

Fig. 770.—Grip devised by Dr. Gordon Morrill for exerting traction on the foot. The operator uses his weight to pull with, and considerable traction can be kept up in this way for a long time with very little fatigue.

(6) Fractures just below both trochanters—(*a*) Transverse, or nearly transverse fractures; (*b*) "spiral" fractures.

(7) Epiphyseal separation, or fracture, of the great trochanter *alone*.*

FRACTURES OF THE HEAD OF THE FEMUR

So far as our data go, these occur not as independent fractures, but as complications of luxations, particularly of luxations by *direct thrust*. Save for the accidental determination of crepitus, for the ease of redis-

* *Isolated* damage to the lesser trochanter is too rare to be classed.

location, and for the help of the skiagraph, we have no way by which these fractures may be diagnosed.

I have met no cases clinically, and can gather nothing of clinical use from the literature about them further than that they may occur.

The treatment obviously calls for the most exact reposition we can attain, and caution as to early use—beyond the caution appropriate to simple luxation. Tendency to redislocation while the patient is in bed may be combated by traction on the leg (Buck's extension with 5 to 10 pounds pull) and a long side-splint.

Fig. 771.—Diagram to show how the head of the bone may be dislocated, leaving a part of the head split off in the socket. Probably the only way in which pieces of the head are split off.

FRACTURES OF THE NECK OF THE FEMUR

Fractures at the hip through the femoral neck or close to it are common in the later decades of life, rare in the earlier periods; but no time of life, not even infancy, is exempt from the chance of damage in this region. Beyond fifty years of age the frequency of the lesion depends, in part, on the lessening of that quick movement, that "easing," of a fall which so often saves us from injury, but, in the main, these fractures occur because as the years go on our bones grow weaker and more brittle. The femoral neck, like the lower end of the radius, loses its actual structural strength.*

Hence it is that in the elderly or aged a slip resulting in a slight fall on the side, or apparently on the buttock, often results in fracture of the neck of the femur. It is this type of fracture of the hip that belongs peculiarly to old age; fractures of the base of the neck or fractures in the region of the trochanters, or just below, may occur at any age, given a trauma acting in proper direction and of adequate force.†

Lesions.—The usual lesion is a breaking across of the bony tissue of the neck, usually close to the head of the femur, at a point where only a thin cortical layer supports a considerable diameter of spongy bone.

The fracture may be close to the head, or it may be a break at any part of the neck. Not very rarely it is near the base of the neck that

* Some stress used to be laid on an alleged increase of angle between the shaft and the neck of the femur coincident with increasing years. The fact of this increase is open to some doubt; its significance is still more doubtful.

† Fractures of the femoral neck proper, common in the aged, may occur even in children. Nor is it always the epiphyseal line that gives way. I have seen fracture of the neck (well outside the epiphysis) without impaction, in a girl of eight, followed, under adequate treatment, by bony union and a good result. Royal Whitman has usefully emphasized the frequency of damage in this region in children and its relation to the development of coxa vara.

the break occurs, and the relations that interest us are then not of the neck and head, but of the neck and shaft.

Commonly, especially where the break is close to the head, the

Fig. 772. Fig. 773.

Fig. 772, Impaction of the neck into the head. Fig. 773, Reciprocal impaction; neck into head on the upper side; head into neck on the lower side (diagram).

posterior wall gives way first, and correspondingly we have an *eversion* of the limb as a whole (Fig. 774).

This occurs whether there be impaction or not. Uncommonly

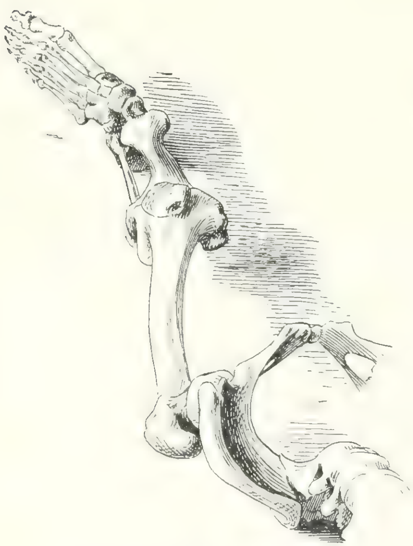


Fig. 774.—Fracture of the hip. Outward rotation of the leg because of impaction of the posterior portion of the neck of the bone.

Fig. 775.—Fracture of the hip. Inward rotation of the leg because of impaction of the anterior portion of the neck of the bone.

(probably owing to a difference in the direction of the fracturing force), we have giving way of the front wall first, and *inversion* (Fig. 775).

Where there is fracture of the neck, even if it is impacted, we have interruption of the vascular supply of the head. Some part of the vessel supply through periosteum and ligament is apt to be preserved, and such supply as reaches the head through the ligamentum teres is undisturbed.

Great stress used to be laid on the distinction between extracapsular and intracapsular fractures in this region, because of this question of blood-supply. In fact, many fractures *traverse* the lines of capsular attachment. The line between the classes is not sharp, and clinically cannot be drawn, and the division has largely been abandoned. Undoubtedly, fractures close to the head are usually entirely intracapsular, but if impaction is present, it makes no particular difference if they are.*

Fortunately, the rule is that hip fractures are impacted, whether intracapsular or extracapsular. According to the direction of the impacting force, the final position of impaction varies. Ordinarily, there is a rotation of the leg and hip back and *out*ward, but impaction in inward rotation is not very rare.

Fig. 776.—Rotation of the head downward and inward as it lies in the socket. Broken surfaces in contact for short space only. This condition may occur with or without impaction.

Impacted Fractures.—

(*a*) Impaction of the neck into the head (Fig. 772).

(*b*) Reciprocal impaction (Fig. 773).

The head may be rotated up or down, as well as forward or back (Figs. 776, 777), but usually such rotation is not extreme. When there is no impaction, or when it is broken up, we may obviously have *any* displacement—any degree of rotation.

There may rarely be a comminution of the main fragments. Not very uncommonly there seems to be not comminution, but *pulverization*, so to speak, of some considerable part of the neck, with considerable loss of length of the neck.† This is more apt, however, to occur in cases without impaction.

* It was anciently supposed that intracapsular fractures involved entire loss of nutrition to the head, and, therefore, inevitable bad results. It must be rare that all vessels are torn; at any rate, necrosis of an *impacted* fragment seems excessively rare. Probably the synovial fluid helps in nutrition, just as we know it does in nourishing the growth of bone-cartilage chips in the joints (this form of "joint mice" shows actual *growth* very clearly, as Codman has demonstrated).

Necrosis does rarely occur in cases without impaction that fail of union, but even here it is the exception, and failure of union in unimpacted fractures in this region is probably largely attributable to the disturbing presence of synovial fluid, not to the lack of enough nutrition in the fragment to allow firm union.

Those familiar with operations on old patellar fractures and other cases of non-union, as at the elbow-joint, know how the presence of synovial fluid inhibits the clotting necessary to the formation of a proper callus. This failure of callus-formation in intra-articular fractures is, I think, extremely important, though apparently unnoted in relation to the question of non-union in most of the later literature.

† Comparable to a like apparent loss of tissue in certain cases of Colles' fracture in the aged.

Damage to the capsule seems apt to be inconsiderable—at all events, we have no sign of it, unless the rarity of occurrence of demonstrable

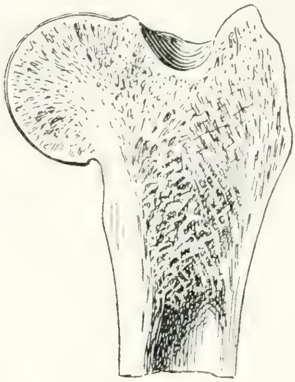


Fig. 777.—Old impacted fracture of the hip; penetration of the inner wall of the neck into the head of the bone; displacement and rotation of the head downward and inward (Warren Museum, specimen 1086).

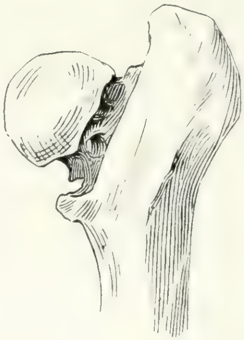


Fig. 778.—Loss of substance of the neck of the femur (Warren Museum, specimen 3651).

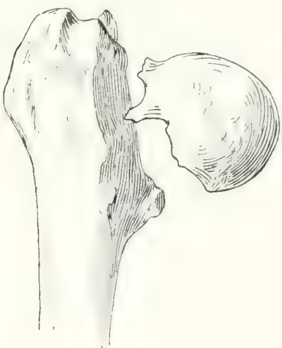


Fig. 779.—Loss of substance of neck of femur (Warren Museum, specimen 8075).

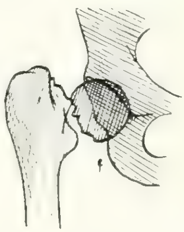


Fig. 780.—Old unimpacted fracture of the neck of the femur, with much loss of substance. Sketch from x-ray. Latter operated on by temporary pegging with serviceable, though not bony, union. (Author's case.)

effusion in the joint may be taken as a sign that the capsule is usually torn and so left open.

No nerves or considerable vessels are in direct relation to the parts or directly exposed to damage.

Symptoms

According as fractures of the neck are, or are not, impacted, our clinical signs vary.

Signs of impacted fracture of the neck:

(*a*) Disability.

(1) Uniformly there is inability to raise the leg from the bed.*

(2) *Usually*† walking is impossible.

(*b*) Flexion, extension, and rotation are limited and usually painful.

(*c*) In cases showing eversion, further eversion is possible, but no inversion can be carried through without undue force.

(*d*) In the rare cases with inversion,‡ eversion is impracticable.

(*e*) There is shortening, but a shortening running only from 1/4 to one inch.

(*f*) There is abnormal prominence of the trochanter, as a rule, due largely to—

(*g*) Loss of normal tension of the fascia lata. (See Figs. 782 and 785.)

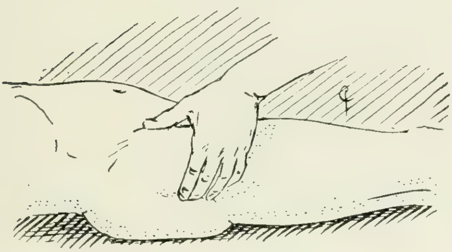


Fig. 781.—Palpation of trochanter by fingers, with the thumb on the anterior-superior spine. The digital fossa may often be palpated in this way.

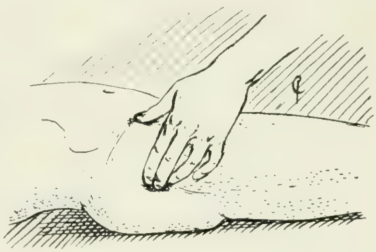


Fig. 782.—Palpation of fascia lata with the fingers, thumb on anterior-superior spine, little finger on the trochanter.

(*h*) There is usually a distinct loss of the hollow corresponding to the digital fossa, behind the trochanter. (See Figs. 781 and 786.)

(*i*) There is almost always a perceptible thickening over the front of the joint.§ (See Fig. 783.)

(*j*) There is not apt to be much local pain, tenderness, swelling, or other of the usual fracture signs.

(*k*) Crepitus, of course, is absent unless impaction is broken up.

* I have seen one exception to this rule.

† I have seen one case in which the patient, a vigorous man, walked some distance without breaking up impaction. He had slight eversion, 1/3-inch shortening, and the x-ray showed impaction of the neck into the head.

‡ Fractures of the femoral neck with impaction, but without eversion, or with inversion, are by no means very rare, but not the type. Their occurrence depends probably on the direction of trauma; the diagnosis is not difficult; the treatment is the same save that reduction of impaction is peculiarly unjustifiable, because they promise better results from conservative treatment than do the everted cases.

§ Walker (Ann. Surg., 1908, xlvii, 84) calls especial attention to fulness in the outer part of Scarpa's triangle, due to the fact that in the most common variety of fracture the head and neck, with the trochanter, are bent backward and downward, thus resulting in forming the apex of a fracture-angle upward and forward.

There is no way, save with the x-ray, to discriminate between "intracapsular and extracapsular" fractures, or between fractures near the head or near the trochanters.

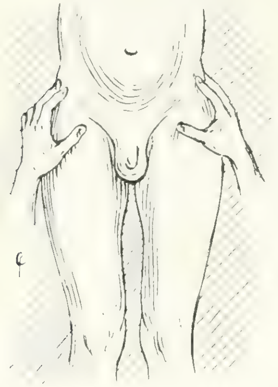


Fig. 783.—Palpation of the front of the joint with the thumbs; fingers on anterior-superior spine and crest.

Signs in unimpacted fractures:

(a) Shortening.

(1) Usually greater than in impacted cases.

(2) *Tending to increase* under the undisturbed pull of the irritated muscles.

(3) Varying with even gentle manipulation, *i. e.*, with intermittent traction.

(b) Disability—more extreme than in impacted cases.

(c) Eversion—more extreme, without any power to invert *actively*.

(d) Lack of any check to passive inversion or eversion.

(e) Rotation of the (palpable) trochanter takes place on a shorter rotation axis than in the normal leg or in an impacted fracture. (This sign is classic, but I think apt to be of little value, because the observation is hard to make out with certainty.)

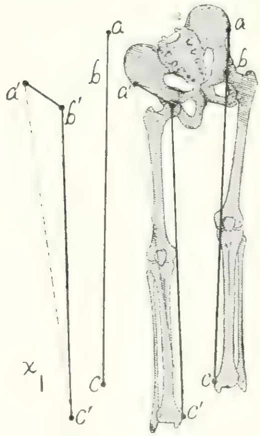


Fig. 784.—The error in measurement of length of the leg; if the pelvis is tilted, the length of the leg on the concave side, so to speak, *i. e.*, the leg that is in abduction, will be less, that of the other leg is more, than if the pelvis were level. This results from the fact that the points a and a', c and c', have no fixed relation to the acetabulum b and b'. The line diagram shows obvious shortening of a' c' as compared with the other side; in fact, the error (in this figure) is shown by the length of the vertical line marked x in the lower left-hand corner—a very considerable error.

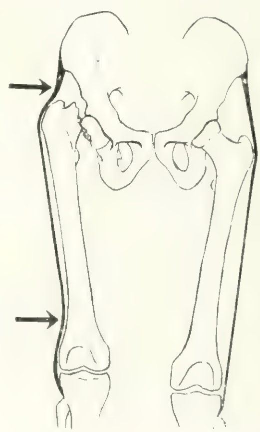


Fig. 785.—Loss of tension of the fascia lata, due to hip fracture. The fascia lata is attached to the crest of the ilium above, to the head of the fibula and its vicinity below. Any break between these points with shortening necessarily slackens the tension of the fascia. This slackening can be felt between the trochanter and the iliac crest. (See Fig. 782.)

(*f*) Crepitus is not always obtainable, often not obtainable except by carrying out rotation, *while strong traction is exerted* on the leg to bring the fragments opposite one another, a procedure obviously unjustified except to confirm a diagnosis *already made* of a loose fracture.

If we wish to demonstrate change in total length, crepitus, etc., a procedure devised by Dr. Gordon Morrill, recently house-surgeon on my service, is worth noting. The procedure is, I think, amply explained by Fig. 770. Its advantage lies in the fact that we may, in this way, exert a traction force of several hundreds of pounds if we wish, and any desired traction may be kept up for a long period without great fatigue to the assistant exerting traction, and without damage to the patient. One may, by this method, readily keep up the pull long enough, for instance, for the application and setting of a plaster spica.

In regard to the broad question of diagnosis, irrespective of impaction:

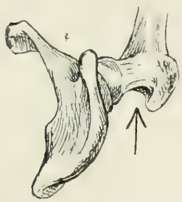


Fig. 786.—Normal right pelvis and femur, seen from above. The arrow at the back shows the digital fossa—a much deeper groove than is ordinarily appreciated.

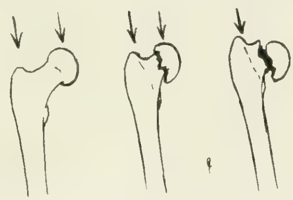


Fig. 787.—Rotation on the long, versus the short, axis. In the normal femur there is a distance corresponding to the arrows in the figure; this is the radius on which the trochanter rotates. If there be an impacted fracture, the mechanism is the same, but the distance (the radius) is shorter. If the fracture be unimpacted, the shaft rotates on its own axis and the distance (or radius) is zero.

Dr. Gay* has long taught what I believe to be sound general doctrine, namely, that in practice there is no such thing as a "strain" of the hip. Certainly it is well within bounds to say that any injury to the hip in an old or elderly person that causes marked disability, that makes it impossible to raise the heel from the bed, that gives deformity in eversion, with loss of possible inversion,—that such injury means hip fracture almost without exception. I have, in fact, seen *no* exceptions to the rule that I can recall.†

The reason for the greater liability of the old to this fracture lies, as noted above, in structural changes in the bone.

* George W. Gay, Lecturer on Surgery to the Harvard Medical School; he has elaborated this and other valuable clinical points in a paper published in the Transactions of the New Hampshire Medical Society, May, 1903.

† Since the above statement was written I have seen one such case—an impacted fracture with eversion and with lengthening, with the leg held in slight abduction. The patient could lift the heel from the bed readily. There was a fracture of the neck, with coxa valga deformity. This is the exception that proves the rule.

One more point is perhaps worth noting, namely, that occasional cases that look like anterior luxations prove to be atypical cases of fracture of neck or trochanters, firmly held in abduction by muscle spasm. If there is any doubt, after palpation, it is better to wait even a day or so for an x-ray rather than do harm by ill-advised attempts at reduction. (See Fig. 821.)

Fig. 788.—Extreme outward rotation in unimpacted fracture of the femur, shown on the right leg (lesion on left is fracture of the lower leg).

As to the frequency of impaction in fractures of the neck, I can only say as follows: the conclusions given are the result of a not inconsiderable experience in a large hospital clinic.

The great majority of cases of the femoral neck *do* show *definite impaction.*

Of late a vast deal has been written of unimpacted fractures of the femoral neck and of their appropriate treatment. I cannot find many of these cases: despite enthusiasm, I have found but four cases of non-impacted fracture demanding operation in a rather long series of years, and recall but few unoperated cases. Here and there, to be sure, perhaps in 10 per cent., one finds unimpacted fractures, but in our hospital cases we find it almost always practical to treat even these much as we treat the impacted cases, *and the results are almost always good.* Almost always they unite, perhaps not by bone, but in such fashion as to give a solid and a reasonably useful limb—and a reasonably useful limb is all we ask of even the impacted cases, for these are ordinarily fractures of persons past the useful years, with diminished capacity both for repair and for functional accommodation.

I confess myself bewildered by the literature of "unimpacted fracture of the neck of the femur," and with all possible reserve I can find no solution unless it lies in undue zeal in examination of cases of fracture which, undisturbed, would keep the peace and give fair results. I give this solution in some chagrin that I cannot find in the large traumatic series at hand more than a few such cases as are constantly reported by others.

Fig. 789.—Unimpacted, ununited fracture, with a good deal of loss of substance. Very little shortening. Sketch direct from x-ray plate.

There are many cases that we class as impacted that the x-ray shows to be hardly more than what we may call *entangled:* the impaction evidently is of little depth or firmness, and doubtless very easy to break up.

In our hospital it is not only the rule, but a very firmly fixed

house-officers' tradition, to be extremely careful about handling these cases.

Perhaps these two facts may help the explanation.

Treatment

If a hip fracture is impacted, the chance of bettering the condition present is small. We have ceased to lay great stress on the distinction between extracapsular and intracapsular fractures, but the fact remains that, in the hip as elsewhere, intracapsular fractures tend to non-union unless they are impacted. Consequently, we should not be strenuous in diagnostic manipulation. It is far better to be vague and to do without too many facts in these cases than to be exact at the expense of breaking up a useful impaction.

If we have the signs above noted, slight shortening, loss of tension of the ilio-tibial band, slight prominence anteriorly, eversion, loss of the hollow at the digital fossa, prominence of the trochanter, etc., but with motion in rotation of the trochanter on a reasonably long axis, we have to deal with a case of impaction, a case we should let alone, as a rule.

In the younger patients, if we have impaction in excessive eversion or with great shortening, active measures may be considered, not only because these cases have more power of repair, but also because fractures in such cases are not apt to be intracapsular, and, ordinarily, unite promptly, while the condition let alone promises serious disability.

In such cases, and in such only, is breaking up of impaction defensible.

Breaking up of impaction may here result in greatly improved position, and such breaking up, with subsequent weight traction in abduction, has at times led to excellent results in my hands.

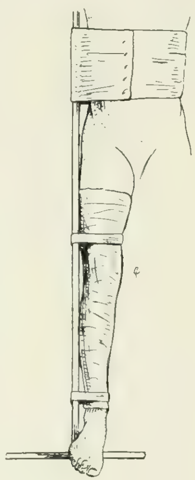


Fig. 790.—Long outside T-splint; extends from the axilla to below the foot. Applied with a swathe to the chest. The leg, with or without a back splint, is strapped to the splint to steady it and to limit rotation.

Such treatment is to be employed only with great conservatism, of course, *and rarely without consultation* to divide responsibility, for the mass of literature does not fully sanction this treatment.

In the average case, where there is impaction, we have a peculiarly serious lesion that we are not likely to make better by active interference.

Our first concern must be the patient, rather than the fracture. These old people not only bear shock badly, but they are peculiarly *apt to die from mere confinement to the bed.* The percentage of deaths in fractures at the hip is rather staggering; it is certainly above 25 per cent., even in non-alcoholic cases. The *proximate* causes of death seem to be heart failure and hypostatic pneumonia, as a rule; the real cause

of death is usually confinement to bed and change of routine. Old people stand such confinement badly, as a rule.*

Often it is wise to neglect the fracture entirely in the interest of preserving life, whether the fracture be impacted or not; often patients who are allowed to sit up without regard to the fracture will "perk up" and be restored to a few years of comfort (in a wheel-chair, perhaps) and possibly to some usefulness, a result which is certainly better than death from hypostatic pneumonia or from sheer inertia.

Often, then, it is wise to treat the patient and not the fracture.

Such treatment is not uncommonly rewarded by a fairly useful limb as well, for sitting up *alone* will not break up impaction, or even greatly hinder union in an unimpacted case.

In case we have an impacted fracture, we may let the fracture alone, and sit the patient up, or we may rely on sand-bags to help inversion (see Fig. 791), or we may put him to bed and use a long outside splint alone (Fig. 790), or we may apply extension with both sand-bags and splint. If such extension is used, it is applied as for fracture of the thigh, but the weight used is only three to six pounds, and the purpose of the traction is not to pull fragments apart, but purely to steady the limb and to guard against sudden twitching of the muscles.

Fig. 791.—Position of sand-bags to prevent leg and foot from rolling outward.

In the run of cases a long outside splint with eversion straps is applied (see Fig. 792); if the patient is muscular or cramps are present, traction is added—about three to six pounds. This is kept up two or three weeks only; if the patient's condition is good, then rest and relative fixation, without weights, is continued until six weeks have passed and union is pretty solid. Then the patient is gotten up in a chair, and presently is allowed to walk with crutches.

In the more favorable cases I do not use plaster bandages at all.

In certain cases, however, that stand confinement tolerably (but not very) well, especially cases that show tolerable muscular strength, we may wisely apply a short plaster spica bandage after two to three weeks, and so enable them to get up on crutches a little earlier.

* Certain old people stand it perfectly well. Dr. H. L. Burrell, years ago, used to call attention to the *types* of old people, as shown in manner and face, who do and do not endure such confinement. Those who "fuss" and who show nervous tension in their faces are those, as a rule, who do badly under these conditions. I have (since this chapter was written) seen an old lady of eighty-four with hip fracture who tolerated bed treatment with perfect equanimity and even cheerfulness. In her case we obtained good results. It is largely a matter of nervous temperament, rather than of physique.

In younger patients such treatment may well be the routine.

Often a sharp *abduction* at the hip, secured by plaster, gives better position of the leg, and so promotes resumption of use of the limb.

If a case is unfit to handle as above sketched, the whole scheme may

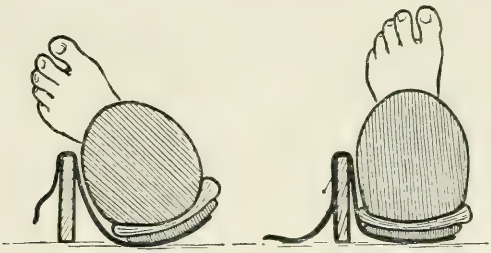


Fig. 792.—Diagram of section of leg and splint to show how a strap carried from the back of the leg over the long side-splint can prevent eversion of the foot and leg.

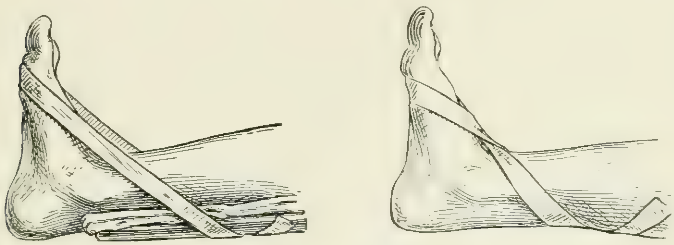


Fig. 793.—Form of stirrup to prevent the foot assuming an equinus position, needful in almost all fractures of the femur at any level.

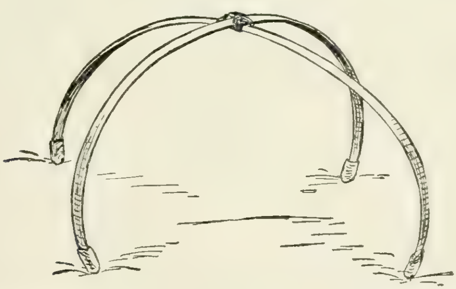


Fig. 794.—Cradle to keep clothes from leg. Made from two barrel-hoops with a little adhesive plaster.

well be abandoned. We should be able, if experienced, to judge of the patient, and what he or she will stand. If things look unfavorable to bed treatment at any time, I do not hesitate to sit patients up *at once*, relying only on sand-bags or pillows to help maintain position.

Treatment of Unimpacted Fracture of the Femoral Neck

We have the choice of—

(*a*) Traction and immobilization (Fig. 795).

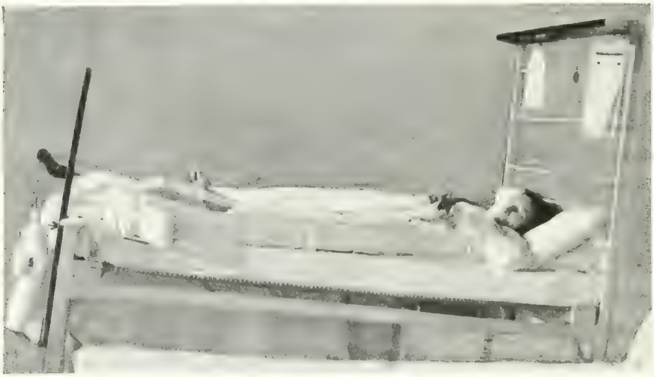


Fig. 795.—Buck's extension apparatus. Adhesive-plaster straps for traction; posterior splint to the leg and thigh; weight traction over the pulley at the foot of the bed. The whole leg steadied by the long T side-splint shown in Fig. 790. Foot of bed raised on blocks to give counter-traction by body-weight.

(*b*) Traction in the line of the shaft *with lateral traction* (Fig. 799).

(*c*) Traction with *abduction* (Fig. 796).

Fig. 796.—Same apparatus applied to give traction in abduction. Traction made from one corner of bed, and this corner raised disproportionally high. To carry this out successfully the T-splint should not reach much above the hip, in order that the abduction position be not lost.

(*d*) Traction with abduction and with *pressure on the trochanter*.

(*e*) Open operation, with or without nailing.

Manœuver (*a*) is ordinarily efficient, but considerable weight is required for the traction—as much as 12 to 25 pounds or even more, and such traction, applied by adhesives, must be watched carefully: the

Fig. 797.—Traction and countertraction to give great *temporary* force for reducing fragments or adjusting apparatus.

skin of older people does not always tolerate such traction without irritation.

If this method is used, fixation with the long side-splint and a well-fitted posterior (ham) splint are called for. Much care is needed to prevent eversion of the foot by the eversion straps (above described) fastened to the long side-splint, or by other adequate device (Fig. 792).

Fig. 798.—Ununited fracture of the neck, with almost entire absorption of the neck.

The removal of weight traction is governed by the progress of the case. After about a month we may begin to test union, both by gentle rotation and by letting an assistant alternately pull down and push up on the foot while we have thumb and fingers on the trochanter and on the adjacent landmarks to detect abnormal motion.

If union *seems* solid, we may decrease and presently remove the weights. Such change must, however, be accompanied by frequent measurements of the limb. Sometimes shortening does not appear until several days after taking off the weights. Whenever it appears, back the weights go until union is solid, or until we give up hope of it.

About two weeks after union *seems* solid it is safe to treat the case as we would treat an impacted case at say five weeks from the injury.

I never feel safe in allowing weight-bearing before eight to ten weeks, and then only cautiously.

Method (*b*) seems to have been a good deal used in the west, and is reported as very efficient. I have had a few cases in which it has been used successfully, but they are too few to generalize on. The method consists simply of the usual traction downward in the line of the leg, with *lateral traction outward* by the pull of a weight on a band running through the groin (Fig. 799).

Method (*c*),—traction in abduction,—that is, traction obliquely down and outward, is accomplished as shown in Fig. 801. (See also Fig. 796.)

Theoretically, the pull of the adductors in abduction should help the short rotators in maintaining contact of the fragments. It is well not to abduct too far, and to control our treatment by careful measurement, for too much abduction may easily *produce* shortening, the adductors acting as a lever.*

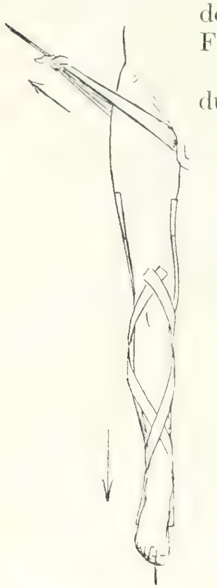


Fig. 799.—Traction in the line of the femur, with lateral traction in the groin. Theoretically wrong, but used with some success.

Fig. 800.—Bradford hammock frame, cut out to facilitate the application of a (right-sided) plaster spica of the thigh.

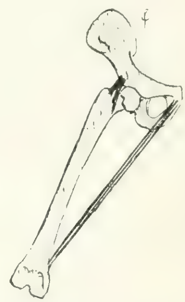


Fig. 801.—The position of a fracture through the head or neck may sometimes be secured by putting it up in abduction. The adductor muscles act as a strap fulcrum, and the broken surfaces are forced in contact.

In applying a plaster spica, abduction of about 20 degrees is the rule -not so much for better position, but because it overcomes the usual limitation of abduction, that is troublesome when the patient first tries to walk.

* Do not forget in measuring to abduct the other leg to an equal angle and avoid the error already so often mentioned. Practically there is no question that skilful "jamming" in abduction is a very serviceable method of retaining fragments in contact. It is a measure that must be applied with skill, because overabduction may easily carry the fragments by one another and do harm.

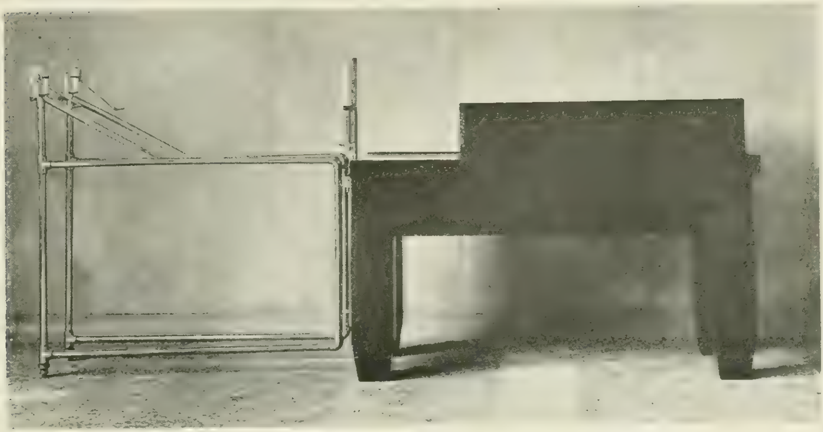


Fig. 802.—Table, modeled after Hoffa's original, for obtaining extension by adhesive-plaster traction and winches; counterpressure in the perineum by means of a 3-inch wooden spindle. Used for reduction, and more particularly for the proper application of the plaster "spica."

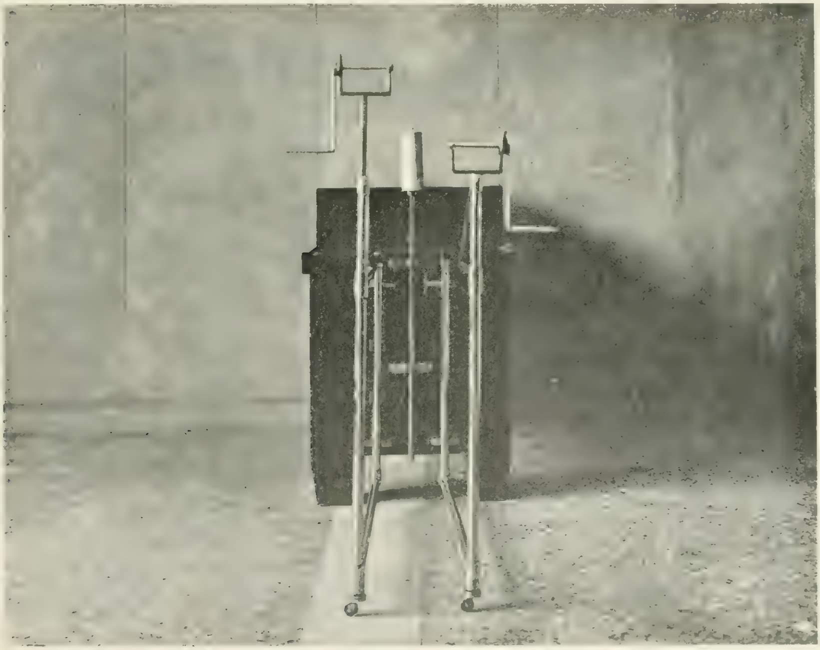


Fig. 803.—Same seen from lower end.

Method (*d*), originally proposed by Senn, consists of the application of a plaster "spica" bandage in which a window is cut over the trochanter; through this window a pad presses on the trochanter, its pressure regulated by a surcingle band about it and about the pelvic part of the plaster bandage. I have no experience with the method; theoretically,

Fig. 804.—"Hoffa" table with patient ready for application of plaster.

at least, it is rational; whether it possesses any real advantage, I do not know.

Open operation (*e*) has been practised in many cases, mostly on cases in which there had been failure of union under ordinary routine.

We have, broadly speaking, two methods: *first*, opening the joint in front and refreshing the fracture surfaces; then, with or without

Fig. 805.—Plaster spica for femur fracture. Put up in plaster about ten days after the accident (delay because of shock). About $\frac{3}{4}$ inch shortening; perfect alinement (photograph by Dr. F. L. Richardson).

nailing, putting the leg up in the best attainable position (usually in abduction) in plaster, with or without traction under the plaster; *second*, external incision with temporary resection of the greater trochanter; the operation so approached is usually completed by nailing of the trochanter, often also of the broken neck. There are but two objections to nailing of the broken fragments: first, the difficulty of stopping the nail short of the acetabulum; second, the tendency of the

nail to erode a cavity for itself, and to become, after weight-bearing is begun, an irritation rather than a support.

Our object in these cases is purely the approximation of fragments; I suspect the nail is not essential, and may, by the irritation of its presence, hinder union.* In the few cases I have operated on such a nail has always been in the "kit," but I have used it but rarely, and the results without nailing have uniformly been very satisfactory—union in all cases was firm enough for walking, though I feel *sure* of *bony union* in only one case.

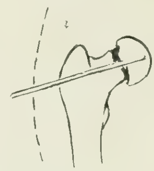


Fig. 806.—Temporary spike to hold head in proper relation.

If we are to use the nail, the rational method seems to be the approach by the anterior incision, denudation of surfaces, insertion of a long spike driven through the skin from the outer side through the trochanter and neck into the head. Such a spike may be removed after a week or two (or longer) leaving no foreign body to make trouble. Moreover, its insertion is controlled (as to depth) by a finger between the fragments. I have used this method with excellent results.

Results of Fractures of the Femoral Neck

End-results in fracture of the femoral neck have not, to my knowledge at least, been adequately studied.

Fig. 807.—Fracture of femoral neck on the right. Slight shortening and adduction; solid union. Going to be a good result.

As has been noted, the mortality is heavy, from causes we cannot control.

Beyond the list of those who die, we have many others in whom the feebleness and infirmity of age make *useful* recovery (even from injuries even much less grave than this one) quite out of the question.

Apart from these cases, however, my impression is that the results are better than is ordinarily assumed.

In the first place, I believe the assumption of *common* failure of impaction or of bony union is erroneous. So far as I know, or can learn, the vast majority recover with *solid* hips, whatever the deformity may be.

These are not normal hips, nor is their function normal. There is shortening; there is loss of power to abduct; there is thickening; usually there is eversion—but they are solid.

* I have seen x-rays of such a case in the hands of a colleague that have somewhat discouraged me in the use of the nail. This objection may readily be met by driving the nail in through a separate incision over the trochanter, and removing it after two or three weeks.

As sequels, we have a limp, some loss of motion, and an added awkwardness of gait from eversion.

But all these disabilities disappear, to some extent, with time and use. Particularly I have noted an accommodative *inversion by muscle action* that, in large part, counterbalances the displacement in eversion.

In short, none of these cases in the elderly, perhaps none at any age, regain a normal hip, but many patients get around very well. I have seen many such, even cases in whom the fracture occurred at eighty years or later. What the percentage of such results is cannot now be stated.

Fig. 808.—Fracture with impaction of the neck of the right femur. Slight shortening, outward rotation, and abduction. All to be seen, but slight. The edema of the leg is the temporary edema almost always present in these cases on beginning use.

Certain few individuals show rheumatoid, or rather "osteo-arthritic," changes, with a good deal of lameness and "rainy-weather pain." Some develop a definite "malum coxæ senile."

The cases with non-union show markedly greater disability, more shortening, more eversion, more pain, more inability to handle or use the leg.

In fact, however, some of these cases get about tolerably well, though with a marked limp and with small endurance. The support of the body-weight is assumed to be the Y-ligament in front, the obturator muscles behind; the upper end of the outer fragment, still in part enveloped in capsule, forms a sort of false joint on the ilium that carries some part of the weight.

Some of these cases may be greatly benefited by an open operation that, with or without pegging or nailing, brings about a rigid union, but such an operation is a major operation in the case of old people.

Those unoperated are always cripples to an extent if there is no union, but it is not correct to suppose that they are always hopeless cripples, unable to walk.

Nor is it correct to assume that non-union of fractures of the neck is a necessary result of unimpacted fracture, even in the old.*

* There come to my mind two cases of loose fracture of the neck in men over

Separation of the Epiphysis

The epiphysis of the femoral head occupies the relation shown in Fig. 800.

Its separation is relatively, but only relatively, rare.

The trauma causing such separation is not apparently different from that causing fracture of the neck. We may have falls on the trochanter or the buttock or on the feet, as a cause.

Whitman* has demonstrated conclusively that fracture of the neck, as well as epiphyseal separation of the head, is not very rare in young children.

The differential diagnosis is not easy.

We can diagnose these cases only by the signs that help us in adult fractures. "Soft" crepitus may help in the diagnosis of epiphyseal lesions. A good x-ray will settle doubts.

The peculiar interest of these cases rests on the curious similarity, which Whitman has shown, between the consequent coxa vara resulting from such trauma and that coxa vara familiar to orthopedists which results from lessened resistance of bone structure, expressing itself oftenest at about the age of puberty.

Fig. 809.—Epiphysis of the head and of the great trochanter. (Warren Museum, specimen 417.)

The shortening is common to both forms, as is also the inability to abduct the leg—actively or passively; there is the same increased prominence of the trochanter, made more obvious by flexion; the x-ray shows the same change in angle between neck and shaft.

Coxa vara of traumatic origin, after consolidation, is amenable to the same operative procedures as the coxa vara dependent on developmental failure, with the same results.

But our effort should be rather to prevent than to repair these deformities.

The moral is that we should be very careful to exclude fracture or epiphyseal separation in any doubtful case, at or before the age of puberty.

If we are on the watch for such a lesion, the *general* diagnosis is not difficult, though differentiation between forms in detail may be difficult or perhaps even impossible without the x-ray.

If we have an eppihyseal separation to deal with, the displacement must be reduced, and *accurately* reduced. A good x-ray is essential, for we can feel but little to guide or test our reduction.

Displacement is of the shaft and neck upward; the epiphyseal head remains in place.

sixty (one of them a notorious alcoholic at that) in whom solid union and very fair function resulted.

* R. Whitman, Med. Record, July 25, 1893; Ann. Surg., June, 1897, *ibid.*, February, 1900.

Reduction is by traction down, with traction outward (applied inside the groin) to carry the broken outer end past obstructions into place. There is no chance of carrying it too far, for the ligaments are substantially intact. Abduction or adduction or rotatory motions may be called for before the fragments fit.*

The leg is to be put up in sharp abduction in a plaster spica.

The result is to be tested by the *x*-ray. If it is not satisfactory, we have no choice but open operation, replacement, and another plaster spica.

If it is not an epiphyseal injury, but a fracture, the treatment must vary to fit the case.

In these cases in children there is no impaction to deal with, nor is an absolute "fit" essential, as with the epiphysis.

If we overcome shortening, the union of bone-ends will take care of itself. Shortening is to be overcome by a Buck's extension, loaded with a weight of 3 to 20 pounds according to age and size, and an outside splint is employed for fixation. After three weeks a spica of plaster-of-Paris is enough.

There is no harm done to children by bed confinement.

There seems to be no chance of non-union.

So far as we know, cases adequately treated do not develop coxa vara, but it is true that the early soft callus may yield to weight, and weight-bearing may well be postponed to six or eight weeks.

Interference with growth does not occur in fracture, and seems vastly rare in the epiphyseal cases, at the hip.

Fractures at the Base of the Neck

Fractures of the neck near the trochanter are, in fact, common. Their occurrence has long been recognized; their *frequency* has been known to us only since the skiagraph became useful.

The trauma is essentially that of the neck fracture; the only difference is that *severer* falls, and at times falls on the foot or knee, appear oftener as the cause. Perhaps this means only that this is less characteristically a fracture of the aged than is fracture of the neck proper.

The lesion is commonly a break at the base of the neck, with more or less impaction of the neck into the trochanter and shaft. (See Figs. 810–818.)

The line of break varies somewhat, and not rarely there is some splitting in the region of the trochanter (see Fig. 812), or an associated spiral fracture running downward.

The degree of impaction varies much.

* And, after all, they may not fit with anything like accuracy. Should we be satisfied with moderate position? I think not, and though without experience of operative treatment on this lession, suspect that it, like separation of the humeral epiphysis, belongs to the operable lesions.

The fracture is, however, very definitely extracapsular, and the formation of callus is prompt and is usually efficient, even if there is no impaction.

Our concern in these cases is purely one of obtaining the best possible position; union may usually be left to take care of itself.

Fig. 810.—Fracture at the base of the neck; impaction of the base into the shaft (diagram).

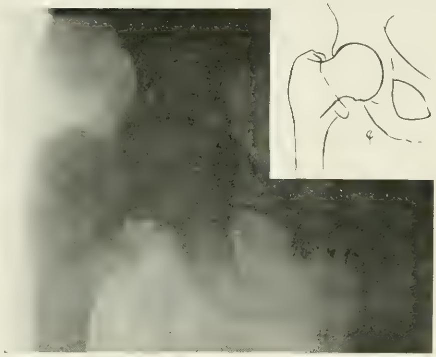


Fig. 811.—x-Ray of fracture of the base of the neck, with impaction of the base of the shaft. Explanatory diagram to the right.

Diagnosis of Impacted Fracture of the Base of the Neck.—We have disability; shortening, ordinarily not great; eversion, sometimes absent, sometimes replaced by inversion; obliteration of the digital fossa.

All these signs occur also in fracture of the *neck* with impaction.

There may be not only filling up of the digital fossa, but marked thickening of the whole region of the trochanters; this usually means fracture at the base of the neck.

Fig. 812.—Fractures of base of neck and of trochanters of femur. View from behind and inner side (Warren Museum).

Fig. 813.—Impacted fracture of base as well as head. Old case (sketch after plate of Cooper).

Fig. 814.—Impaction of the neck of the femur into the shaft, with a splitting of the trochanter.

Beyond this, we must depend on the skiagraph to differentiate between the two lesions.

If, by chance, such a fracture is wholly unimpacted, we are again

confronted with the question of differential diagnosis as against unimpacted fracture of the neck proper.

Diagnosis of Unimpacted Fracture of the Base of the Neck.—The signs are: total disability; shortening, *varying* with intermittent traction; loose eversion, with active inversion impossible, passive inversion unhindered; rotation of the trochanter on *its own axis* when the leg is rotated; prominence of the trochanter under an entirely relaxed fascia lata.

Fig. 815.—Similar lesion to that in Fig. 814. Specimen from Oldknow's case (sketch after Cooper's plate).

Fig. 816.—Fracture between neck and shaft and fracture of great trochanter; partial impaction. Union so imperfect that fragments separated in maceration (Warren Museum, specimen 1075).

Fig. 817.—Fracture of the neck of the femur and of the great trochanter, in section. Impaction; union not firm (Warren Museum, specimen 5225).

Fig. 818.—Fracture of femoral neck. Impaction of base into the shaft, with downward and inward rotation of upper fragment (Warren Museum, specimen 6303).

Fig. 819.—Fracture well below trochanters, with a split running upward through great trochanter. Also fracture of neck of bone, with displacement of head up and outward. Recent case. (Warren Museum, specimen 1074).

In short, there is nothing that definitely distinguishes these from like loose fractures higher up in the neck. Usually we are content with the approximate diagnosis and wait for the x-ray.

As we first see these cases, they are apt to lie in bed or on a stretcher, in a position strongly suggesting a subpubic luxation, and not uncom-

monly, if a little time has elapsed since the injury, muscle spasm is such as to fix the hip almost immovably in this position. In some cases of this sort in stout patients even the fracture diagnosis can hardly be made at all, save by the skiagraph.

Treatment of Fractures of the Base of the Neck

In *impacted* cases, if the deformity is not great, we treat as with impaction of neck into head, merely to preserve impaction. The details of the treatment are the same.

If the position, however, is bad; if shortening, adduction, or external rotation promise much deformity and disability, we may wisely consider breaking up the impaction to improve position, without fear of nonunion, because these fractures are definitely extracapsular.

Before doing this we must have a good x-ray to make sure in detail just what we are dealing with.

In etherizing cases for such breaking up I have often found them to show no firm impaction at all; so soon as the muscles relax we have a loose fracture.

In these cases, after dragging down the shaft into proper relations and letting the patient come out of ether, the muscle spasm (returning) becomes a factor that helps in fixation. For the rest, the case is treated like the obviously unimpacted ones.*

In the *unimpacted* cases we first reduce, as well as may be, with or without ether, according to the need and according to the fitness of the patient, and then attempt to hold reduction by the methods used in unimpacted neck fractures of the usual type.

Fig. 820.—Spiral fracture of femur through and below trochanters, with fracture of the base of the femoral neck, partly impacted into the shaft.

Reduction is by a pull on the foot, with counterpull on a sling in the perineum, with appropriate rotation.

To maintain position we usually apply extension straps and use weight traction (8 to 25 pounds). Lateral traction may be called for, but can be applied later if the position calls for it.†

Sometimes position is best secured in sharp abduction. This may

* I believe the time is coming when it may seem wise, in these cases, perhaps in all unimpacted fractures of either neck or base of neck that are fit to etherize, to *produce* impaction by driving home the trochanter (protected by felt, of course) with a heavy mallet. I have done this in one case with admirable results.

† Lateral traction seems to me an undesirable and unnecessary *routine*. The objection to it is that it necessarily interferes with circulation somewhat, and ordinarily is not particularly comfortable and probably not very useful.

be attained by abduction-traction with weights, or, if abduction holds things without any pull, a plaster spica alone (without traction) may be enough, or traction straps may be put on underneath and covered with the plaster spica, and we get the fixation, combined with more or less efficient weight traction, during the time the patient is in bed.

The choice of methods is purely one of judgment of the individual case. Some cases are very readily held; others are almost impossible to treat satisfactorily.

Traction may usually be omitted after three to four weeks. Fixation, or at least non-use, may wisely be continued until six weeks have

Fig. 821.—Unimpacted fracture through base of neck and through trochanters. Note extreme eversion and thickening in groin. Position was improved, and firm union resulted, with a useful leg. (From photo of case of the author's.)

passed. During this period, however, massage and careful *passive* movements are in order.

Resumption of weight-bearing must be cautiously begun.

Prognosis

Good in the main. If there has been undisturbed impaction, there is no question that union will take place. There is some shortening, usually some eversion, and a moderate limitation of motion, due in part to bone thickening, in part to fibrous changes during the immobilization necessary to insure repair.

Union is solid, and we may expect eventually a serviceable result, with no worse damage than a slight limp and slight stiffness and moderate pain on use, decreasing with time.

If there has been no impaction, prognosis depends largely on adequate treatment. With good reduction well maintained, the result is that of the impacted form.

Disability is present in less successful cases about according to the displacement persisting after union.

Delay in union is not uncommon; weight-bearing, therefore, is to be delayed in such cases for eight weeks or more.

Non-union is rather rare, even in neglected cases.

FRACTURES THROUGH THE TROCHANTERS

These fractures—by no means uncommon—are usually the result of rather severe trauma. Commonly, they are met with in young or middle-aged patients in whom the structure of the femoral neck still retains its strength.

The causes are: (*a*) Direct violence. (*b*) Torsion of the leg.

The lesions in the torsion fractures often show a combination of a torsion fracture (with spiral lines) through the trochanters, combined with a fracture between the neck of the femur and the intertrochanteric line (Fig. 820).

Breaks *directly* across, between the level of the greater and lesser trochanters, are rare. They are from direct violence usually. Such lesion may accompany a break at the base of the neck, perhaps from splitting of the trochanteric neck by this basal fragment. (See Fig. 816.)

Torsion fractures may break the bone above or below the lesser trochanter; the iliopsoas is attached to this process, and the determination of the site of fracture with reference to this insertion is not unimportant, but these fractures clinically belong with those wholly below the trochanters (class 6, p. 480).

Diagnosis of Fractures Through the Trochanters

(1) Complete disability.

(2) Much thickening at and behind the trochanters; obliteration of the digital fossa.

(3) Eversion (permanent), usually present, though not constant.

(4) Limitation of motion.

(5) Shortening—not necessarily great.

(6) Impaction, actual at times, often only apparent, but apparently very definite in nearly all cases examined without ether.

(7) Crepitus is rare.

(8) Rotation shows, if there is *any* impaction, a greater trochanter

rotating on the head as an axis, without obvious change from the normal radius: *loose* rotation does not belong to this type.

Usually the greater thickening is our best diagnostic point. *Positive* diagnosis is often dependent on the skiagraph.

Treatment

The treatment is substantially that outlined for fractures of the base of the neck.

Results

Non-union of fractures in this region I have not met. The fracture is distinctly extra-articular, and callus-formation is usually profuse.

Given a reasonably good reposition, we get in these cases very good results indeed. There may be some shortening and consequent limp; there may be thickening enough to limit in some measure the movements at the hip, but, as a rule, such disabilities are not great and the results are usually good.

FRACTURE BELOW THE TROCHANTERS* (CLASS 6)

We have no insertion of any of the shorter hip muscles below the break, and therefore no apparent impaction from muscle spasm. Impaction is extremely rare. Therefore we find:

(1) Disability—total.

(2) Shortening—often great.

(3) Extreme outward rotation, from gravity, as in shaft fracture.

(4) Flexion and outward rotation† of the upper fragment (by the iliopsoas muscle). (See Fig. 827.)

(5) Abduction of the upper fragment by the gluteal muscles. (See Fig. 826.)

(6) Free mobility of the leg in all directions, *including inward rotation.*

(7) Crepitus (not always readily obtained).

(8) Failure of the trochanter to rotate with the leg or to share its other motions.

(9) Possibility of testing the *varying* length and the looseness of the leg by direct intermittent traction.

In short, we have in these fractures below the lesser trochanter the picture of high fractures of the shaft.

The diagnosis in detail is often difficult; swelling is apt to be considerable, and differential diagnosis is obstructed by the difficulty in reaching the various landmarks.

* Many fractures do not anatomically fall either in this class or in class 5, but belong to both. Clinically considered, the important matter is whether the main fracture runs below and outside the insertions of the short hip muscles, and particularly of the iliopsoas.

† Not as constant as the text-books declare it, but usual.

According to our skill, we may approach accuracy in this matter, but for *exact* diagnosis a good skiagraph is apt to be essential. In no

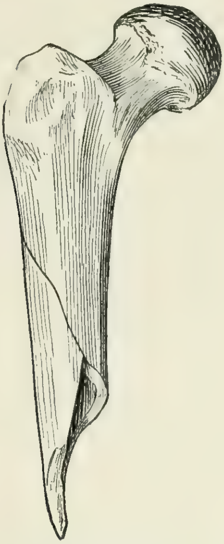


Fig. 822.—Spiral fracture of the upper part of the femur. View from in front and externally (Warren Museum, specimen 1103).

Fig. 823.—Spiral fracture of the upper half of femur. Viewed from behind (same specimen as Fig. 822). (Warren Museum, specimen 1103.)

fracture is our ordinary hospital routine as to *x*-rays more unfortunate

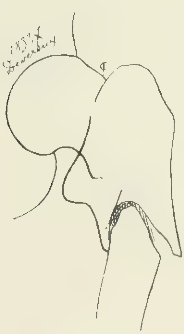


Fig. 824.—Fracture below trochanters, outward bowing.

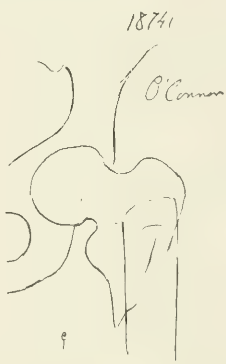


Fig. 825.—Fracture below trochanters; shaft firmly impacted into trochanters. Clinically like impacted neck, though with somewhat more thickening (writer's case).

than in various hip fractures. We have too often permitted the difficulties in transportation of these cases to interfere with their proper

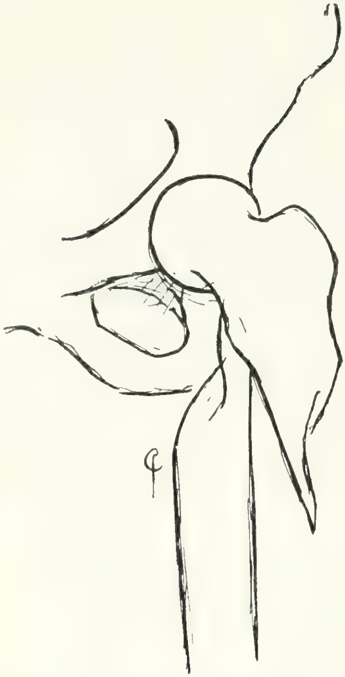


Fig. 826.—Spiral fracture just below trochanters. Abduction of upper fragment. No impaction, but firm entanglement of upper end of lower fragment (sketched from x-ray).

Fig. 827.—In fracture below the lesser trochanter, not only do the abductors act, but the iliopsoas (drawn in black) pulls the fragment into flexion.

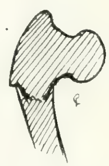


Fig. 828.—Diagram of similar deformity in fracture *above* lesser trochanter. Here there is no flexion pull, but even more liability to abduction (better leverage for abductor muscles).

Fig. 829.—Fracture of shaft of femur very high up; union with much displacement (Warren Museum, specimen 5993).

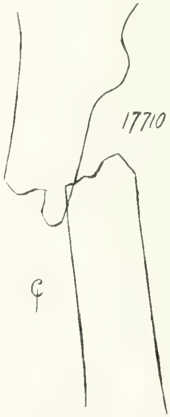


Fig. 830.—Fracture of shaft high up; typical abduction of upper fragment, due to muscle pull (compare Figs. 824–826).

diagnosis, though accurate diagnosis is here essential to proper treatment.

Treatment of subtrochanteric breaks consists essentially of proper

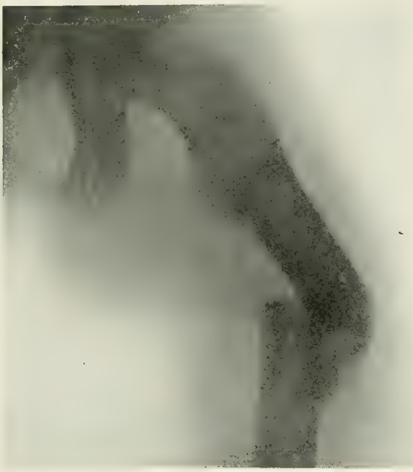


Fig. 831.—x-Ray, fracture below lesser trochanter; flexion and great abduction by muscle action

Fig. 832.—Sketch of x-ray of case of unimpacted fracture between trochanters, with *no* deformity from muscle pull.

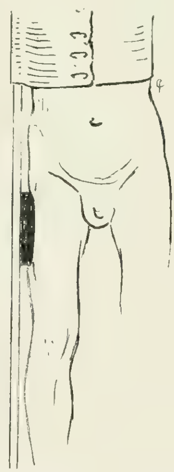


Fig. 833.—Pad inside the long side-splint, to limit abduction deformity.

coaptation of fragments with traction. Fractures in this region are not impacted. According as we find the upper fragment abducted by the gluteal muscles, or flexed by the iliopsoas, we must endeavor

to correct this displacement or to place the shaft in line with said upper fragment.

This may call for abduction or for flexion; much may be made out

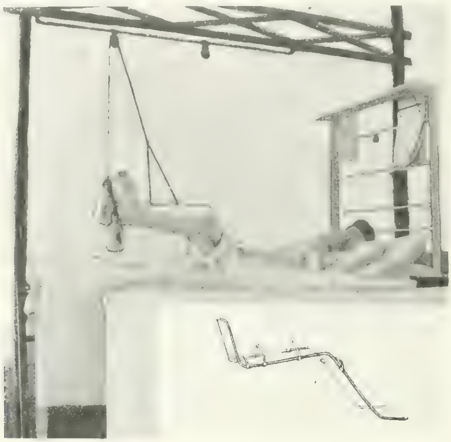


Fig. 834.—Anterior suspension splint for cases of high femur fracture, with much flexion of upper fragment. The splint (see lower drawing) is of iron wire; it is padded, and the leg and thigh firmly bandaged to it (from behind and below); then pulley ropes are slung to the rings in front, and the weight traction arranged to give the pull in the desired line. This plate is a photograph of a case in which extreme flexion of the upper fragment could successfully be met only in this way.

by skilful manipulation as to what the displacement is, but we are aided by the skiagraph. If abduction is called for, we must employ either sharp abduction, maintained by a plaster spica, or traction in abduction.

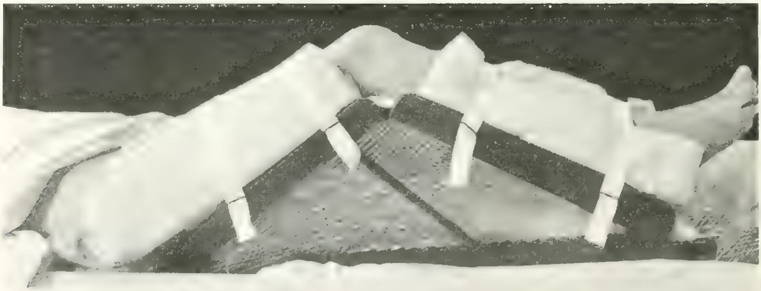


Fig. 835. Double-inclined plane splint, padded and applied. Fracture at junction of middle and lower third. Very old man. Died. (Courtesy of Dr. F. L. Richardson.)

Sand-bag pressure on the upper fragment, or a pad between the long Liston side-splint and the leg, is often effective as an aid (Fig. 833).

If flexion is called for,—and this measure is less often called for than we should suppose from reading the text-books,—then we must use

the Smith or Hodgen splint, or the much-vaunted, rarely used, double-inclined plane. Our endeavor in these cases is to overcome shortening and angular displacement; therefore we exert the necessary trac-

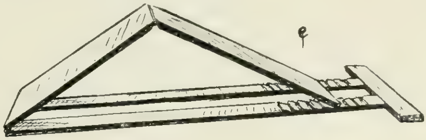


Fig. 836.—Double-inclined-plane splint, adjustable.

tion *in the line of the displaced upper fragment*, the position of which we cannot easily influence. This end is often more simply accomplished by traction in the direct line or in abduction *without* flexion, because the

Fig. 837.—Vertical suspension for high femur fracture in a child. Adhesive-plaster traction bands as for usual "Buck's." Coaptation splints to thigh. There should be pull enough to bring one side of the pelvis slightly off the bed. This is the best apparatus to use to bring the lower fragment in line with a flexed upper fragment. By children it is well borne; for adults it is intolerably uncomfortable.

tendency to flexion is slight or readily reduced, and easily held in many cases.

It is only in fractures *well below the lesser trochanter* that such compensatory flexion is likely to be needed, and in these cases, even, it is

often uncalled for. Sometimes it is possible to bring the tilted upper fragment down by the steady pressure of a sand-bag applied directly over it.

Broadly speaking, we are apt to find it wise to treat fractures in this region by traction in abduction, followed by a plaster spica (in abduction). Each case must, however, be judged by itself, and or-

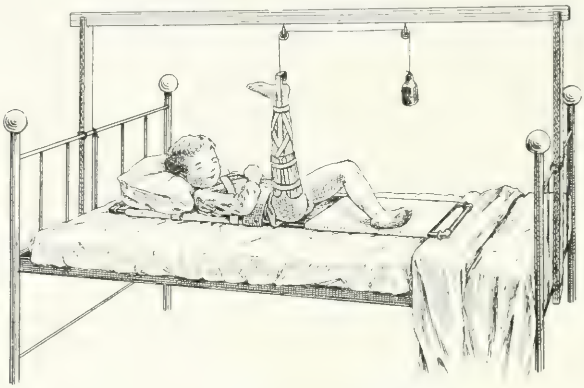


Fig. 838.—Same apparatus with varying detail. High fracture of thigh in a child. Bradford frame. Vertical suspension of leg with weight and pulley. Coaptation splints to thigh, and fixation of pelvis by towel swathe about frame.

dinarily we have three checks as to the perfection of our reduction: (*a*) the measurement of shortening; (*b*) palpation of the end of the upper fragment; (*c*) the *x*-ray.

Given a reasonably accurate reposition, we have little trouble as to the union of these fractures. Callus is usually profuse and solid. Care

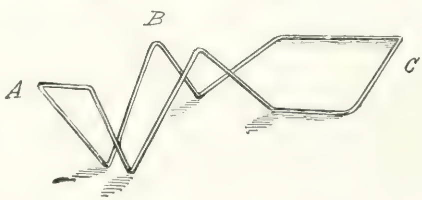


Fig. 839.—Cabot splint arranged as double-inclined plane: *B*, The part behind the knee-joint may be bent to a more acute angle; *C*, the body portion; to be molded to the trunk; *A*, the foot-piece.

must be taken as to early mobilization, and particularly as to early weight-bearing, for these fractures are rather liable to late progressive deformity under too early use.

There is some tendency to deformity in anterior bowing, but more particularly to outward bowing under weight, even with good position and apparently solid union. Such tendency is to be avoided by avoid-

ance of early weight-bearing; if it already threatens, pads of felt, etc., with fixation in flexion or abduction in plaster, will tend to neutralize it. Fractures of this sort are rarely fit for weight-bearing under ten weeks.

FRACTURE OF GREAT TROCHANTER ALONE, OR SEPARATION OF ITS EPIPHYSIS

These lesions are uncommon.

They may occur from direct violence, more often from muscle pull.

The trochanter may, so long as it remains an epiphysis (up to eighteen years) be torn loose from its bed.

Fig. 840.—Separation of the cartilaginous epiphysis of the great trochanter (Warren Museum, Specimen No. 1190). (I can obtain no history of this specimen or of the cause of the epiphyseal separation, but there are signs in the dry specimen of obvious inflammatory process from the neck of the femur down to the point shown by the white arrow in the figure, involving at least the periosteum and the epiphyseal line (probably acute epiphysitis) (age about twelve years).

In adults, the trochanter, no longer an epiphysis, may be torn out of place.

Diagnosis.—The diagnosis is by direct palpation. The damage to the trochanter is apt to be overlooked at first.

There is tenderness about the trochanter, and on careful examination, perhaps a movable fragment.

There is, of course, no shortening, and disability is not complete. Active abduction is necessarily abolished; other motions are painful.

Treatment.—The conservative treatment is that of fixation in abduction, with pad pressure over the trochanter. Consolidation will take three to four weeks.

Open operation and nailing have been proposed and carried out. There is little to say against it, but not much to say for it, except for the gain in time from solid contact as a start for union.

So far as I know, no disability has been reported in these cases when conservatively treated.

It would seem unlikely that even fibrous union would give any disability if position was good.

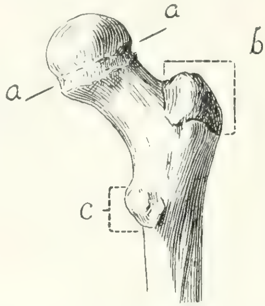


Fig. 841.—Upper end of femur in a child: *a, a,* Line of junction of epiphysis of head and shaft; *b*, epiphysis of greater trochanter; *c*, epiphysis of lesser trochanter (Warren Museum, specimen 334).

In case of difficulty in retaining the fragment in place there would be every reason for immediate operation.

FRACTURE OF LESSER TROCHANTER

This lesion occurs often as a complication of spiral or splintering fractures. As an independent fracture it is recorded by Julliard.* He gives marked external rotation and absolute helplessness as the signs. The diagnosis was confirmed by autopsy.

* Julliard: Arch. f. klin. Chir., 1903, Bd. lxxii, p. 82.

CHAPTER XXIV

THE KNEE

DISLOCATIONS

Dislocation at the knee—separation of tibia and femur—is a very rare accident, far rarer than one might expect, considering the great force under great leverage to which the joint is often subjected. Most commonly, knee luxations are fracture luxations in which splitting off of one or the other femoral condyles or of the tuberosities of the tibia has permitted lateral displacement. Rupture of single ligaments alone—particularly of the internal lateral ligament—may commonly enough give *sub*luxation.*

Anteroposterior displacements are not apt to involve bone damage.

Fig. 842.—Landmarks of knee from outer side: *a*, Tubercle of tibia (insertion of ligamentum patellæ); *b*, edge of outer condyle; *c*, patella; *d*, top edge of tibia; *e*, head of fibula.

Anterior Luxation of the Knee

Displacement of the tibia forward at the knee results from great force acting by direct thrust or, probably, through hyperextension. The lesion occurs not through a fall, as a rule, but in some form of crushing or twisting accident.†

Such displacement involves rupture of the lateral ligaments and either rupture of the strong posterior ligament or its separation (by stripping up of the periosteum) from the back of the tibia. Vessel and nerve injuries are not unusual.

Diagnosis.—Displacement is obvious; the only question is as to associated fracture, a question to be answered by palpation of landmarks and by cautious manipulation of the lower leg by an assistant while the surgeon palpates the region of the knee.

Lateral mobility is present, of course, since all ligaments are gone. Hyperextension is possible. Flexion is more or less hindered.

Reduction.—The most efficient reduction is by hyperextension with

* The name of "strain fractures" has lately been given to such knee lesions—not a bad term, for the *luxation* usually reduces itself. (Sidney Lange: Ann. Surgery, 1908, xlviii, p. 117.)

† Eames (Brit. Med. Journ., 1900, i, 908) gives an instance in which a car in a mine dropped 60 yards down a shaft. Of the 18 men in it, 5 sustained forward luxation at the knee.

downward traction, and direct manipulation to force backward the displaced tibial head. This succeeds, but is open to the objection of possible stretching of the nerves, especially of the external popliteal.

Fig. 843

Fig. 844

Fig. 845

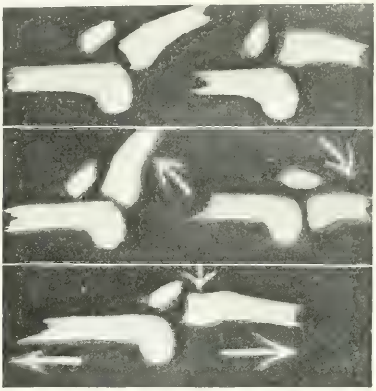


Fig. 843, Anterior luxation, occurring by hyperextension, may give the position shown at the left, or by later traction may come to lie as in the right-hand sketch. Fig. 844, In the latter case the movements here shown (hyperextension, then traction with direct thrust) will be called for. Fig. 845, If there is no overlapping, simple traction and countertraction with a direct reducing shove will suffice.

Traction and direct pressure *without* hyperextension seem, from the recorded cases, to be efficient without this risk, and should be tried first.

Treatment is by fixation in plaster, aided by massage after a fort-

Fig. 846.—Forward luxation of the knee (from a severe crushing accident); left leg, seen from the outer side (photographed for author, courtesy of Dr. H. A. Lothrop).

night, with passive motion at about a month. Weight-bearing must be resumed cautiously and late, for the substitution of scar tissue for ligaments so powerful as the posterior and laterals at the knee takes weeks, and is apt to be somewhat imperfect at best.

Therefore a light split-plaster or a leather and steel support, worn while walking, is advisable for some months, mobility and the preven-

Fig. 847.—*x*-Ray of same case. No fracture. Reduced readily by Dr. Lothrop, by mechanism shown in Fig. 844. Did well.

tion of muscle wasting being assured by massage and by *active* motion with the apparatus off.

Backward Luxation

This is less common. The diagnosis is again obvious from the presence of the exposed condyles in front and the obvious backward displacement of the leg. The patella disappears into the intercondylar groove. (Fig. 848.)

Reduction is to be accomplished under traction by direct pressure forward on the displaced tibia, with counterpressure on the femur in front.

Fig. 848.—Backward luxation at the knee, right knee, from the outer side (schematic).

INWARD LUXATION

This is excessively rare without fracture. The diagnosis calls merely for the exclusion of fracture of the condyle or of the tibial tuberosity (established by palpation when the knee is moved). Reduction is by traction and pressure.

Inward *sub*luxation is even rarer—it is to be dealt with similarly.

OUTWARD LUXATION

This is a bit commoner; the displacement is usually in part rotatory in the direction of outward rotation. Not rarely there is concomitant outward displacement of the patella to the outer side of the external condyle. Of course, the direction may be outward and forward or, more often, out and backward.

The diagnosis is obvious.

The reduction in this form also is by traction and direct pressure, with or without rotation.

Subluxation Outward.—This is not uncommon as the result of apparent rupture of the internal lateral ligament. There may be actual subluxation, or, more often, simply a mobility in the joint *permitting free play in abduction.* This motion commonly reaches 20 degrees or more. In these cases there may be tearing of the internal lateral ligament to some extent, but apparently the tearing of the vastus internus and its enveloping fascia is a very important factor in permitting lateral motion.* The only case I have seen operated (Crandon) showed this sort of tearing, but *no* obvious damage to the ligament itself.

It is because "ruptures" of this ligament seem, in fact, not to involve any tearing of the ligament *in mass* that the prognosis of these cases is so good.

Fig. 849.—Posterior and outward luxation (strictly subluxation) of the knee, with fracture of inner part of tibia into the joint. End-result here shown; much disability. (Case of the author's in 1893, before the days of x-ray confirmation and study.)

Fig. 850.—Congenital luxation (genu recurvatum). Sketched from a plate by Barth (Arch. f. klin. Chir., 1884–85, pl. ix, Fig. 2).

Prognosis of Knee Luxations.—In all uncomplicated knee luxations the prognosis, if there be no complications, is better than would be expected. The torn ligaments repair, and a mobile joint results, with fair strength.

There is a risk of progressive knock-knee from any of the complete luxations and in fracture-luxations, especially in the outward luxa-

* Lateral motion of a *few* degrees is of no consequence in diagnosis—it not uncommonly appears in knees that have shown synovitis for a few days.

tions, owing to imperfect repair of the heavy internal lateral ligament on which, normally, a great strain is thrown.

Congenital Luxation of Knee

There is a luxation of the knee forward—"genu recurvatum," illustrated in Fig. 850—that should be mentioned. It is congenital, and is often associated with partial or total defect of the patella. The condition permits of effective reduction with good function if the knee is straightened *early*.

Dislocation of Semilunar Cartilages ("Internal Derangement of the Knee" of Hey)

There are in the knee two cartilages, an outer and an inner, attached at their ends to the tibia, and held at the peripheral edge by the so-called coronary ligament, which is really a part of the capsule. The inner edges are free. The cartilages move with the tibia in flexion and extension, but probably act as sliding "buffers" in the slight abduction and adduction movement of the joint, and certainly do so act in rotations of the tibia on the femur. Their normal range of motion, like that of other interarticular cartilages, is slight.

Dislocation of one or the other cartilage may rarely occur without any tearing: the "coronary ligament" attachments may be lax. Ordinarily, however, the cartilage, before displacement takes place, is torn loose at either end, or its peripheral attachment is loosened, or, perhaps the most common lesion of all, the cartilage is torn across.

Such tearing may be associated with *immediate* displacement. This, however, is not the rule; usually the first trauma shows only a synovitis as the obvious result, and later some slight twist of the knee brings about a dislocation.

What we meet with in practice is ordinarily the recurring dislocation —*habitual* dislocation of the cartilage.

The tearing of the ligaments or of the cartilage, in the first place, is supposed to be caused by the cartilage becoming caught at one point between the bones, and then, by traction in the rotatory movement, torn loose or torn across. I have always suspected, however, that the transverse clean-cut break across the middle of the cartilage must be a fracture under extreme *pressure*.

In the habitual cases there may be a thickening of the broken ends, or, more commonly, a thinning; one or the other end may be doubled over. There are not usually any concomitant joint changes unless recent luxation has left a synovitis.

Dislocation may be toward the center of the joint, or, less usually, toward the periphery. In case the cartilage itself is torn, only one fragment luxates. It is very doubtful if any factor other than trauma enters into these cases. Shaffer maintains that a long patellar ligament

is the constant predisposing cause. It might well be, but the presence of such a lengthened ligament in the actual cases has not usually been confirmed by other observers.

Falls or slips involving a twisting of the knee are commonly the cause of the original damage, as of the recurrent displacements. Once the displacement has become habitual, rotation of the knee in slight flexion under very light force may cause it, more particularly if the muscles are relaxed.

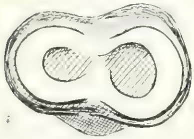


Fig. 851.—Right tibia at knee-joint (from above), showing size and relations of the two semilunar cartilages.

For this reason a slight slip of the toe at the completion of a step or an unguarded movement in bed is, in inveterate cases, more likely to give displacement than is a more forcible twist.

Symptoms.—Whichever cartilage is displaced, and in whichever direction the displacement may be, the main symptoms are the same—a sudden "locking" of the knee in slight flexion. So long as the knee is kept flexed there is no great pain, and the sufferer can walk if he does not fully extend the leg. But so soon as extension comes to a point somewhere within 20 to 15 degrees of the straight line, motion is absolutely checked, and there is excruciating pain from pinching of the cartilage. Some one has aptly compared the mechanism to that of "a stone in a hinge." If reduction is not prompt, a sharp synovitis develops, and there is reflex muscle spasm. After reduction the synovitis is often not severe, and in the frequent inveterate cases where the patient has learned to do instant reduction himself, the reaction is trifling or none at all.

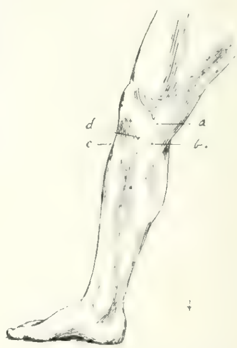


Fig. 852.—*a*, Region of tenderness in strain of internal lateral ligament; *b*, upper edge of tibia; *c*, tibial tubercle; *d*, internal semilunar at point most often damaged.

In all cases, however, habitual dislocation leaves the patient justly fearful, whatever work or sport he engages in. Rarely, the tendency to luxation lessens with time; often it tends to grow worse.

In any given instance where the cartilage is out it stays out until reduced by some manœuver. There is only rarely any tendency to spontaneous reduction.*

Diagnosis.—Similar symptoms may be given only by a "foreign body" in the knee, a loose cartilage of the "mouse" type, or by pinching of a fringe of ligament (the free edge of either of the ligamenta alaria, outer or inner). No other conditions give the locking in extension with free function in flexion. Differential diagnosis between

* In strict fact, in recurrent cases use and motion of the joint do sometimes throw a cartilage in, inasmuch as they involve the various rotations.

a pinched fringe and a cartilage may be impossible; fortunately, the treatment is the same. A "mouse" may be suspected if other "mice" can be felt in the joint, or if the offending body can be felt as a *rounded* mass, or if there is a history of previous locking not caused by any *particular* motion of the knee. The locking caused by a foreign body is often very sudden and sharp: so far as I know, the sort of locking that throws a man off his feet never occurs from a jammed semilunar cartilage.

With semilunar displacement we have the locking at a definite point, short of full extension, with exquisite pain on either the outer or the inner side. Usually there is nothing objective to be felt; occasionally the luxation is peripheral and the cartilage may be felt as a cylindric mass lying outside the joint.

Such a displaced cartilage is tender to the touch; even when nothing is to be felt, there is tenderness *over the site of the displaced cartilage.*

Diagnosis as between displaced inner and outer cartilages rests on

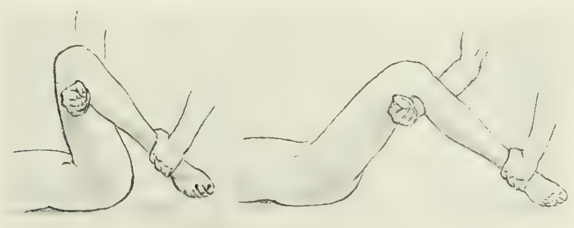


Fig. 853.—Reduction for dislocation of internal semilunar cartilage. Flex leg over bent wrist, at the same time abducting the leg and rotating it outward. This increases space to the inner side. Then extend; with a space to slip in, the cartilage is dragged into place by its lateral attachments.

the localization of pain and tenderness. The history may also help; a twist of the foot *outward* typically leads to displacement of the *inner* meniscus; the outer is usually displaced by a twist inward. Displacement of the inner meniscus is far the commoner injury.

Treatment.—Reduction of the displacement depends on the relief of the pressure on the cartilage between femur and tibia, giving it room; and then on pulling it back into place by utilizing its movement with the tibia in rotation. The exact mechanism of this has been interestingly worked over by Tenney,* though the rules for reduction have long been established.

For our present purpose it is enough to say that whether the cartilage is displaced in or out, the pull of rotation tends to bring it into its own proper position. The motion needed for the right pull is that of rotation of the leg away from the injured side, *e. g.*, outward rotation if it is the inner cartilage that is displaced.

* Ann. Surgery, July, 1904, vol. xl, p. 1.

Reduction of displacement of the *inner* meniscus is best carried out as follows:

The patient is placed on his back; the operator puts his forearm in the hollow of the partly flexed knee; then, grasping the ankle with the other hand, he flexes the leg forcibly over the forearm fulcrum so as to separate the joint surfaces; then, still keeping up this separation, he rotates the leg outward, then brings it up into extension and inward rotation. There is no click—the test of reduction is the possibility of full extension without pain.

Fig. 854.—Shows the origin of the gastrocnemius from the back of the femur above the condyle, and the mechanism by which contraction of the gastrocnemius causes backward and downward rotation of the lower fragment of the femur.

The manœuver may need several repetitions.

At times pressure on a palpable cartilage edge will help.

With a lean leg and a strong-handed assistant holding the thigh, it is possible to abduct the bent leg a little during rotation. This helps.

Some cases, curiously enough, reduce with a rotation against the rule, *i. e.*, inward rotation for displacement of the internal cartilage.

Ether is not often necessary. Properly done, the reduction may be forcibly done with very little pain; there is no point in doing forcible extension.

Reduction of the displacement of the outer meniscus is the exact reverse in the rotation; otherwise the manœuver is the same.

After-treatment.—Fixation in extension until the synovitis subsides. If it is the first time the accident has happened, longer fixation *may* cure it; in recurrent cases it is of no use to try it. You may as well bandage the knee and allow walking. Shaffer has devised a rather complicated apparatus to control rotation and so prevent the slipping of the cartilage. With this, worn for a long time, he has had cures, but the method is too tedious to find many followers.

Fig. 855.—The forms here shown, in which muscular action plays no part, are clinically about as common as those in which the muscle does act.

Under proper aseptic conditions operation will give prompter and more certain results, and is to be advised in the troublesome chronic cases and in the rare cases where, after weeks of neglect, the cartilage has become irreducible.

The stitching down of the cartilage is not always satisfactory the modern operation is a removal of the cartilage, or of such part of it as becomes displaced, through a small oblique incision at the side of the joint.

The loss of the cartilage in no way interferes with perfect function of the joint, nor is the long axis of the leg perceptibly changed.

FRACTURES OF THE FEMUR NEAR THE KNEE

Fractures of the femur near the knee may be classified as follows:

(1) Fractures above the condyles.

(2) T-fractures.

(3) Epiphyseal separations.

(4) Fractures of either condyle alone.

(5) Fractures of a small part of either condyle ("strain fractures").

Fractures Above the Condyles

Fig. 856.—Fracture, oblique, above the knee, united without other deformity than that of overlapping (sketch from Cooper's plate).

These are not very rare. The classic picture is that of a transverse fracture, displaced in backward rotation by the backward pull of the gastrocnemii. (See Fig. 854.) Such fractures do occur, but, as a rule, the gastrocnemii play but a small rôle. The action of the powerful thigh muscles, tending to shortening of the limb, is much more important. Overlapping is the rule, but, ordinarily, it is overlapping as in Figs. 855 and 856, rather than the type of Fig. 854.

The problem is one of shortening rather than rotation, a problem to be met by vigorous traction.

Treatment calls for active traction, and only rarely for the double-inclined plane, etc. Traction by Buck's extension, with a supporting ham splint, applied after the best possible reduction under ether, is the treatment ordinarily most effective.

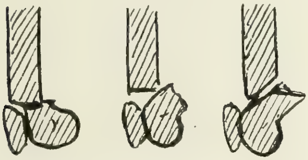


Fig. 857.—Shows how the motions of the patella may be interfered with by the lower end of the upper fragment in various positions of fragments. Moderate rotation backward of the lower fragment is in this regard not a disadvantage.

There is massive thickening; non-union does not occur, apparently; the question is one essentially of motion at the knee.

The question of function is, in a measure, dependent on the relation of the patella to the upper fragment, if the latter is displaced forward (Fig. 857).

Ordinarily, the massive callus thrown out in the repair of these cases, as much even as any rotation or displacement of fragments, is the cause of limited motion and disability. The prognosis, on the whole, is fair—not better than fair, though a useful leg may be looked for. These fractures seem not apt to cause vessel or nerve damage.

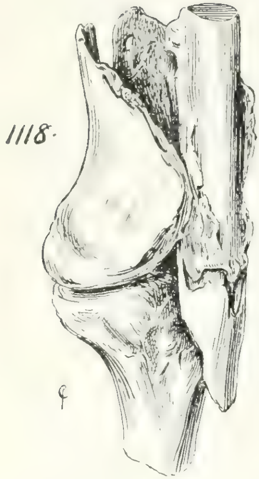


Fig. 858.—Oblique fracture of the shaft just above the knee, with splitting apart of the two condyles. Extreme displacement; necrosis of tip of upper fragment. Patient, a man of thirty-seven years, lived for five months. (Warren museum, specimen 1118.)

Fig. 859.—Posterior view, same specimen as Fig. 858, showing splitting apart of the two trochanters. A high T-fracture.

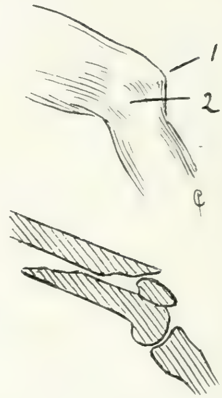


Fig. 860.—Diagram showing the condition in a case of the writer's (very similar to case shown in Figs. 858 and 859) in which traction was utterly ineffective, and operation was refused. There was eventually penetration of the spear-pointed fragment at the place marked 1 (2, external condyle). The patient finally came to thigh amputation after sloughing over the fragment.

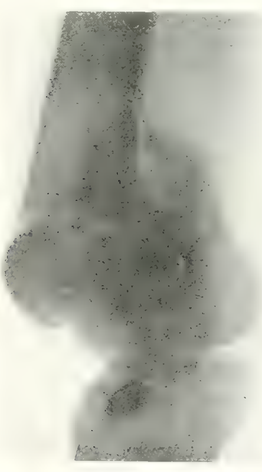


Fig. 861.—Fracture of the femur just above the knee, produced by gunshot (see bullet near level of joint). The bullet wound healed by first intention, but the photo shows marked displacement (here again without much rotation) and a position such that the lower end of the shaft directly impinged on the patella. The patient declined operation, and as she was elderly and not vigorous, it was not urged.

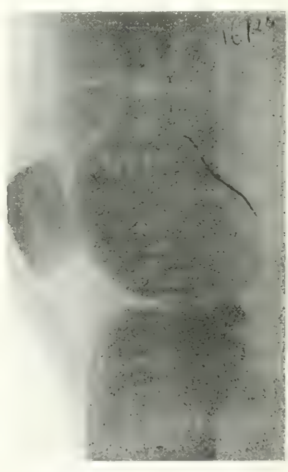


Fig. 862.—Same case as Fig. 861, with position modified only by continued traction, and by the use of pads. Note the excellent position, and particularly the changed relation of the lower end of the shaft and patella. The leg united firmly in this position, with fair motion at the knee.

T-Fractures

These are not very common lesions. Substantially they result from the same violence that oftener gives supracondylar fractures—falls on the knee. The height of the cross-break varies greatly; the vertical split runs straight to the intercondyloid notch.

Diagnosis depends, as differentiated from simple supracondylar fractures, on widening of the knee (in the bicondylar width) and on *separate* mobility of the two condyles, with crepitus. This crepitus in itself is not reliable, for attempts to move the condyles separately will give crepitus betweeen condyle and shaft that is very confusing.

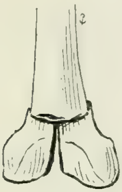


Fig. 863.—Diagram of T-fracture of the femur. T-fractures may be lower; not rarely they are a good deal higher than this.

Fig. 864.—A common deformity in fractures near the knee-joint is that shown above; a simple sagging back, due to gravity, having nothing to do with rotation of fragments due to gastrocnemius action.

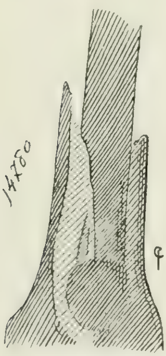


Fig. 865.—Sketch from x-ray plate. High T-fracture. Recovered with some broadening of the bones and considerable limitation of knee motion, but with a pretty serviceable leg.

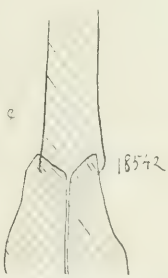


Fig. 866.—Drawing from x-ray plate. High T-fracture of the femur. Good position.

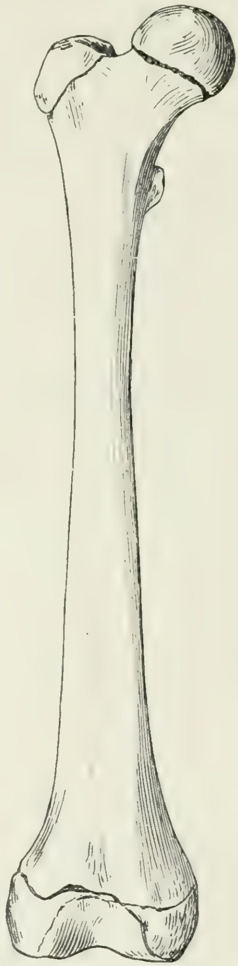


Fig. 867.—Femoral epiphyses at fifteen years. Note relations of lower epiphyseal line to inferior articular surface (Warren Museum, specimen not numbered).

Treatment is by traction and manipulation, preferably under ether. It has been my experience that continued traction (Buck's extension)

tends to produce marked improvement in the relation of one condyle to the other, as well as in the relation of both to the shaft.

Theoretically, mutual impaction of the condylar fragments with mallet and sand-bags, after the best practicable reduction, should be indicated, but the reduction in my more recent cases has been apparently too good to justify the measure, so I have no data to give.

In the manipulation, however, strong *pressure* on the condyles from both sides is most useful.

Prognosis in these cases must be carefully stated. Because of disturbance of relations of the joint planes of the femur, it is apt to be distinctly less good than in supracondylar fractures. If our reduction has been poor, the result may be very poor indeed; on the other hand, we *may* get an almost perfect leg.

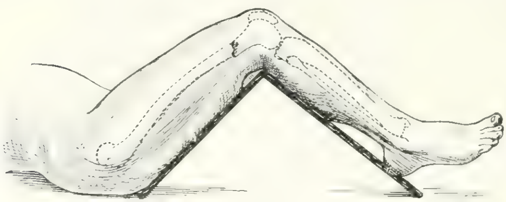


Fig. 868.—Diagram of double-inclined plane for fractures near the lower end of the femur. Secures good position through relaxation of gastrocnemius muscle and pads beneath lower fragment.

Fig. 869.—Traumatic separation of epiphysis of femur. Note in this case the stripping up of the periosteum which has remained attached to the epiphysis. (Warren Museum, specimen No. 9771.)

In the average case, handled with skill and fair luck, we may expect a strong leg, with perhaps 60 degrees of flexion. Such a result is to be called very good. I know nothing of the operative treatment of these cases; they involve the knee joint, of course, and necessarily imply much trauma from the accident, and would call for much trauma in attempts at replacement. One would rather not operate if operation could be avoided with fair prospects.

Epiphyseal Separations

The lower epiphysis of the femur is the largest epiphysis in the body. Its separation is important not only from its size, but also from its proximity to the vessels and nerves of the popliteal space. The epiphysis may be separated at various ages in various ways, but the type case (constituting a fair majority of the cases occurring) is the separation by hyperextension in boys of ten to fourteen years of age. The mechanism is usually that of pure hyperextension. The knee is hyperextended, and the strong posterior ligament tears off the epiphysis.

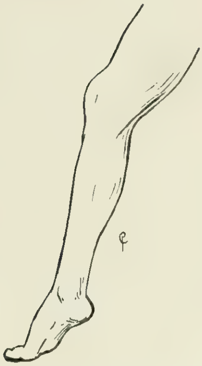


Fig. 870.—Character of deformity in the more usual *anterior* displacement. Compare plates in Figs. 872–875. The displacement in these cases is much less obvious than would be expected from the degree of separation of the fragments.

Fig. 871.—Sketch of the deformity in a case of back and inward displacement seen 24 hours after injury. Injury resulted from twisting the knee in jumping off a wagon; there was backward and inward displacement of the whole epiphysis, with a projection of the end of the shaft of the bone to the outside of the patella, and a marked bow-leg deviation of the general axis of the leg. Reduction under ether required a good deal of traction and force, but presented no real difficulty.

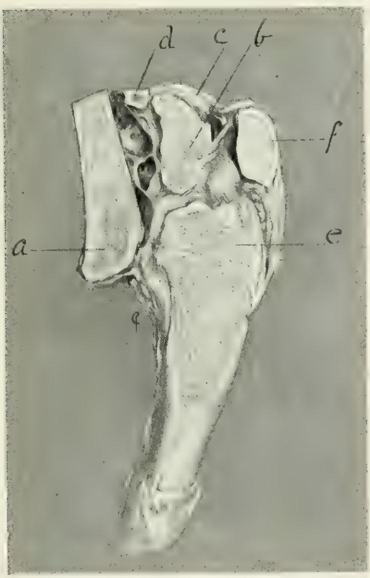


Fig. 872.—Separation of lower epiphysis of femur with forward displacement: *a*, lower end shaft of femur; *b*, lower epiphysis of femur displaced and rotated forward; *c*, front articular surface of this lower epiphysis; *d*, chip of bone torn loose from shaft; *e*, epiphysis, upper end of tibia; *f*, patella. (Warren Museum, specimen No. 8116-1; alcoholic specimen.)

Fig. 873.—Separation of the epiphysis with forward displacement. Detail of displacement exactly as in Fig. 872.

Causation. The trauma is curiously constant; the hyperextension is brought about by the rotation of a wagon-wheel—the boy has been caught in the wheel while "hanging on behind." Nearly all the cases I know of have been from this peculiar accident.

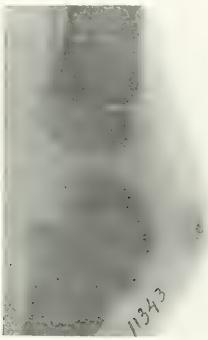


Fig. 874.—Separation of the epiphysis with a chipping of the lower end of the shaft in front. In this case, there never was any more displacement than is here shown.

Fig. 875.—In this case the epiphysis was simply loosened and a little displaced, but presented no difficulty in replacement and no tendency to come out of place.

The epiphysis is torn loose, and as hyperextension continues, it it is driven forward and upward between the end of the shaft and the patella.

Diagnosis.—The position assumed is that of Figs. 870, 872, and 873. The lower end of the diaphysis obviously comes into such position

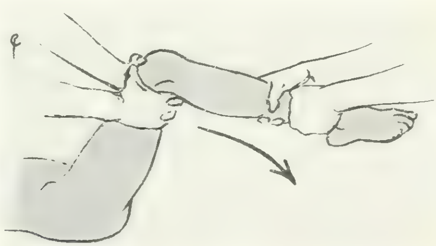


Fig. 876.—Reduction for anterior luxation of the epiphysis. Flexion of hip and knee; femur held firmly and traction made in the line of the lower leg, with constantly increasing flexion; pressure is made on the lower fragment with the thumbs. With variations in the angle at which the knee is held at the beginning of the movement, this is probably the best method of reduction.

that the popliteal vessels are exposed to compression. Rarely they are torn; usually they are compressed. Often also the popliteal nerves, particularly the external, are damaged.

The history of such forward displacements is a melancholy one. There have been many cases of gangrene from vessel damage, and

many deaths subsequent to such gangrene. Death, or amputation to avert such death, seems to be the usual sequel.*

Reduction.—The surgical indication in such cases would seem obvious. If there is displacement with loss of distal circulation, we must interfere—without incision if we succeed in adequate replacement, with open operation if this does not work. The one unjustifiable measure is delay.

Open incision makes it possible to use direct traction (with hooks) to reduce the fragments. If this should fail at first, radical cutting of any periosteal or other obstructing bands is obviously called for. Resection should never be necessary.

Reduction without incision is by traction on the flexed lower leg (see Fig. 876) and pressure downward on the site of the fragment. This is followed by *cautious* extension. If extension causes displacement, reduce again and put up in *flexion*.

Fig. 877.—Old *backward* dislocation of the epiphysis of the femur, caused by fall backward in which the lower leg was immovably jammed. Photograph shows the case five months later. The arrow shows the point of projection of the lower end of the shaft of the femur. Union solid.

Fig. 878.—Same case as Fig. 877. x shows the prominence above referred to. This is the best extension possible because of the rotation of the joint and lower fragment backward (compare with Fig. 879).

If the epiphysis is once *accurately* reduced, with or without incision, the tendency to recurrence is slight, the repair is prompt, the result almost perfect.

*Of 22 cases referred to in the Cbl. für Chirurgie, 1898, xxv, p. 175, there were four deaths and 14 amputations.

The after-treatment ordinarily will be in plaster, with the leg straight or nearly so. If we find any tendency to recurrence of displacement on

Fig. 879.—x-Ray of case shown in Figs. 877 and 878.

Fig. 880.—x-Ray of case shown in Figs. 877–879, *after* operation. This case was operated on by chiseling the end of the shaft clear and making a new bed for it in the mass of epiphysis and callus. In this new socket the shaft was sutured into place after straightening the leg into proper position. The result was a leg perfectly straight, with slight local deformity, ninety degrees of motion, and perfect function.

Fig. 881.—x-Ray of case shown in Fig. 871, after reduction. Perfect reduction. The boy was walking on this leg in six weeks; result perfect.

Fig. 882.—Fracture of external condyle (sketch from Cooper, Pl. xvi, Fig. 3).

extension, it will be well to use the flexed position that is, a position of moderate flexion maintained with plaster-of-Paris. (The double-inclined plane has the disadvantage of liability to popliteal pressure.)

Hutchinson and Barnard have proposed and used acute flexion*—a very reasonable scheme in cases otherwise refractory, but obviously an uncomfortable scheme for the patient.

Union is prompt, function is good if replacement is early and exact.†

In displacement of the epiphysis *laterally* we have no especial problem of vessel trauma to consider. Reposition is accomplished by traction and direct pressure. These cases are very rare. I have seen but one.

Displacement of the epiphysis backward is less common than the forward displacement, but a number of cases are on record; two

Fig. 883.—Reduction in *backward* displacement of the epiphysis; shows the grip by which traction downward in the line of the thigh and a lift forward (against counterpressure at the point shown by the arrow) may be so employed as to carry lower leg and epiphysis forward to the proper position. This was the reduction used in case shown in Figs. 871, 881.

occurring in my practice are noted. Forced flexion, with or without torsion, seems to be the determining force. (See Figs. 877-880, and 871 and 881.)

The displacement is directly back or back and to one side. The rotation is apt to be backward, as shown in Fig. 879. There is no especial liability to tears or tension of either vessels or nerves.

* J. Hutchinson and Barnard: Lancet, 1898, ii, 1630; Med. Chir. Trans., lxxxii, 77. Plummer (Ann. Surg., xxxv, p. 662) has recently recorded his successful use of the method.

† Stimson records a case of loss of growth, credited to Pusey. Andrews (Ann. Surg., 1901, p. 663) has gone into the study of end results fully.

Diagnosis, as distinct from supracondylar fracture, depends on the age of the patient, the height of the injury, the presence of soft, not bony, crepitus, and the skiagraph.

Reduction is by traction on the leg with the knee bent (see Fig. 883), with direct pressure on the protruding fragment; rocking from side to side and varying the angle of flexion may assist the reduction.

Here, as in the forward epiphyseal displacement, the success of reposition is measured by the loss of deformity and the loss of any tendency for it to recur.

After-treatment in all these cases consists of two to four weeks' rest—then gradual use.

Repair is far more prompt than in most fractures at this level, and there is no tendency toward any gradual increase of deformity later.

Recovery of motion is better than in fracture, if reposition has been good.

Fractures of Either Condyle

Fractures of the internal or external condyle alone occur by avulsion as a result of forced abduction or adduction of the extended knee, more commonly than as a result of direct violence. The accident is rather rare. The line of fracture varies. (See Figs. 882, 884.) There is little tendency to displacement, except as controlled by the traction of ligaments running from the broken fragment to the tibia. With the leg straight at the knee a little displacement of the broken condyle away from its fellow is all we have.

Fig. 884.—Lines of fracture of the femur at the knee (diagram of usual types); 1–3 and 2–3 represent the types of fracture of the external and the internal condyles; lines 4–6 and 5–7 are rather epicondylar fractures, and result from avulsion of these portions of bone by ligament, what Sidney Lange aptly calls "strain fractures."

Diagnosis depends on lateral mobility of the joint, with motion of one condyle following the motion of the lower leg. Crepitus will usually be present.

Reduction is by restoring the axis of the leg and pressing the loose fragment into place and holding it there with pads. The leg is, of course, held on a ham-splint or in plaster. Early massage and motion are in order; weight-bearing is not to be hurried.

Prognosis is good according to the accuracy of the reduction. In the best cases we get admirable results,—not far from the normal function, but in the run of cases there is considerable loss of flexion at the knee.

Fracture of the Epicondyles

Here and there we find cases where the ligaments under strain have pulled off smaller fragments, little more than the areas of bone to which they are attached,* fragments that leave the bone-shaft practically

* A very interesting lot of cases of this class are reported by Sidney Lange, "Strain Fractures," Ann. Surg., xlviii, 1908, p. 117.

intact. (*Cf.* Fig. 930, showing like lesion of the tibia.) Clinically, they give the picture of ruptured ligament. Sometimes a loose fragment is felt, rarely crepitus, or the *x*-ray first brings the fracture to light. Displacement is trifling; fixation gives a good result.

Sometimes direct trauma acting at a single point on the flexed knee drives in a portion of the articular surface of the femoral condyle—usually the inner. There are no signs of such damage except local tenderness at one point; there is apt to be a sharp synovitis, but this proves nothing. Tenderness is apt to continue long, but eventually recovery is usually perfect.

The results of *later* loosening of such depressed fragments in relation to the formation of "joint mice" have been interestingly discussed by Codman.*

At the time of injury diagnosis is apparently not possible; treatment, therefore, is likely to be that of the accompanying synovitis only.

* E. A. Codman, in a paper presented to the Suffolk District Med. Soc., April 25, 1903, reported in the Boston Med. and Surg. Journal.

CHAPTER XXV

DISLOCATIONS OF THE PATELLA

Only two classes of dislocations of the knee-pan fairly deserve consideration the outward and the rotatory. All the others, up, down, back, and in, occur as accompaniments of other injuries, not independently (for instance, the upward luxation accompanies "genu recurvatum" or is the result of rupture of the patellar ligament, and the luxation is in itself unimportant).

OUTWARD DISLOCATION

This is the direct outward displacement of the patella onto or beyond the ridge of the external condyle. More commonly the knee-pan is

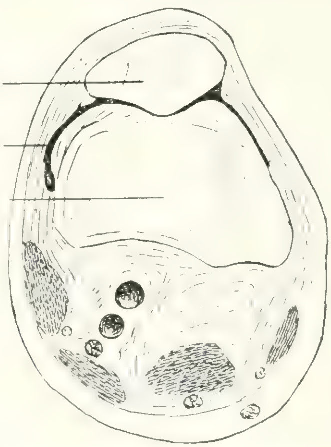


Fig. 885.—Horizontal frozen section of the knee-joint.

rotated, so that the articular surface lies next the bone (Fig. 887), but it may rest on edge* (Fig. 888) or be rotated further back and completely reversed, the articular surface facing forward.

The dislocation may be the result of violence acting directly on the knee-pan from the inner side, but fully as often it results from sudden muscle action.

* On either the outer or the inner edge, for rotation may be either way.

Where produced by muscle action only, the occurrence, and especially the recurrence, of the displacement is apt to depend on knock-knee and on deficient development of the external condyle.

Fig. 886. — Diagram drawn from the dry bones.

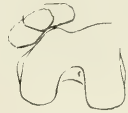


Fig. 887.—Diagram of the forms of the outward dislocation of the patella without rotation.

Fig. 888.—Outward luxation of patella with rotation (diagram).

The case histories show that sudden muscle contraction with the leg extended or in moderate flexion, especially if the knee is turned in or the foot and leg sharply everted,* suffices to cause the displacement. A glance at Fig. 891 will show how the quadriceps muscle, acting on the insertion of the ligamentum patellæ, must,

Fig. 889.—Outward dislocation of patella without rotation. Old case unreduced. (Warren Museum, specimen No. 1187; plaster-of-Paris cast.)

Fig. 890.—Same case as Fig. 889. It will be noted that in flexion in this case there is a sharp outward rotation and some subluxation backward of the lower leg on the femur. This subluxation is not characteristic of the fresh traumatic case. (Warren Museum, specimen No. 1188, plaster cast.)

on contracting, tend to straighten its length (Fig. 891), including its sesamoid, the patella. There is nothing to resist this save moderate capsular resistance and the ridge of bone on the outer con-

* Eversion of the leg obviously brings the insertion of the ligamentum patellæ farther out—farther from the axis of the thigh and its muscles.

dyle, never as high as on the inner side, and sometimes very trifling indeed.*

Lesions.—In cases of direct examination (autopsies, etc.) the capsule has been found torn toward the inner side of the patella in a majority of cases, but not in all. Tearing away of the vastus internus occurs not infrequently.†

Symptoms.—The leg is useless. It may be found flexed or extended—more often somewhat flexed, with sharp limitation of further flexion. Voluntary extension is lost, but passive extension is practicable. The patella is fixed firmly in its abnormal position.

Fig. 891.—Shows the oblique pull of the quadriceps in cases of knock-knee, favored by excessive toeing out and consequent outward rotation of the tibia. If the quadriceps (1) with the insertion of its tendon on the tuberosity at (3) contracts, the obvious tendency is to pull the patella from its position at (2) to a point at (4) approximately in a line between the muscle belly and the insertion of its tendon—*i. e.*, between 1 and 3. It is on account of this fact that the slipping of the patella is rather apt to happen in stout non-muscular women with some knock-knee and pronated feet.

Diagnosis.—We have a hard body, attached to quadriceps and patella tendons, lying, firmly held, to one side of a joint in which the patella is missing, with all other landmarks in place. The rounded surfaces of the condyles are practically subcutaneous and readily identified.

The position in regard to rotation of the patella may be made out by palpation. The external surface of the patella is smooth and flat, and sufficiently attached to the skin to give a dimpling that will help identify this surface. (See Fig. 894.)

Reduction.—Any motion in extension *may* reduce.

The classic manœuver is to flex the hip (to relax the rectus) while extending the knee, and then to shove the patella inward, so shoving as to correct any rotation present at the same time. Pressure and traction downward on the lower part of the quadriceps muscle are also advised.

Ordinarily, reduction is easy. In case the manœuver above described fails, like manœuvers in flexion (moderate flexion, that is) have been reported successful.

After reduction there is, of course, some synovitis, but the damage repairs in the usual way. A ham splint for a fortnight or three weeks and then a bandage and massage suffice.

Prognosis.—In the cases due to direct violence without favoring bone-deformity, complete restitution is to be expected.

* As to the question of mechanism, von Meyer (Arch. f. klin. Chir., 1882–83, xxviii) reports the best work published to date.

† Tenney: Ann. of Surgery, 1908, xlviii, p. 723, records an interesting operation on a *fresh* lesion of this sort. There was a tear, to the inner side of the patella, of 5 inches in length with a gap of 1½ inches. The vastus internus was torn.

In cases due to muscle action we must remember the frequency of underlying anatomic causes; moreover, we have, besides the original causes, the laxity of the joint due to muscle atrophy, to capsule distention, and to possible defective repair of the tear in the capsule. Prognosis will, therefore, be given guardedly.

Unreduced luxations of this type do not necessarily prevent walking, but do put normal active extension out of the question.

RECURRENT OUTWARD LUXATION OF THE PATELLA

Recurrence of this luxation may occur only occasionally—usually unexpectedly in the course of flexion motions; or it may recur very frequently, the patient learning to put it back himself. It involves in time a relaxed and uncertain joint.

The tendency to recurrent luxation may be relieved—sometimes cured—by a specially fitted knee-cap of steel and leather, or even by bandaging. Of more radical methods, we have a choice between reefing the inner side of the capsule (with or without opening the joint) and transplanting the insertion of the patellar ligament inward.* These operations have been done repeatedly with good results.

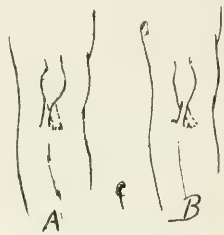


Fig. 892.—Transplantation of the ligamentum patellæ to cure habitual outward dislocation of the knee-pan: A, transplantation of whole tendon inward; B, Goldthwait's improvement on this, by which the tendon is split, the outer half separated, carried under inner half, and given a new attachment to the tibia, well to the inner side.

INCOMPLETE OUTWARD LUXATION

This lesion does occur. It calls for no discussion, except for mention of the possibility of overlooking or mistaking the condition present. Reduction is easier, but otherwise differs in no way from that for the complete form.

INWARD LUXATION OF THE PATELLA

This luxation, complete or incomplete, is extremely rare, if it ever occurs. Certainly the cases on the basis of which it is entered as a type seem unsatisfactory.

Incomplete displacement in this direction seems plausible. Reduction would simply be the reverse of that used in outward luxations.

* Goldthwait (Boston Med. and Surg. Jour., 1904, cl, 169) has successfully treated several cases by splitting the tendon, cutting the outer half at its insertion, carrying it behind the intact half, and inserting it to the inner side of its old insertion. He claims improved results.

ROTATORY LUXATIONS OF THE PATELLA

The patella, as a result either of external violence or of muscle action, may be rotated on its vertical axis without moving out of its proper situation.

This rotation may be of any degree and in either direction. The knee-pan may lie on edge, with the articular surface facing inward or outward, or it may come to lie so that the articular surface faces forward, having come to this position through either outward or inward rotation (Fig. 893).

Lesions. Save for damage to the capsule, probably constant, there are no recorded lesions.

Symptoms and Diagnosis.—There is pain, of course, and the leg is

Fig. 893.—Rotatory dislocation of the patella without lateral displacement; rotation inward or outward though a right angle; rotation in either direction through 180 degrees.

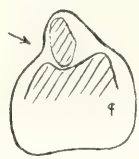


Fig. 894.—Most important is the question of "dimpling." The attachment of the patella to the subcutaneous structures in front is close and tough. It must be an altogether exceptional case in which the "dimpling" of the skin will not give an indication of the direction of rotation.

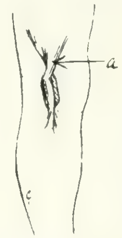


Fig. 895.—In rotations of the patella of 90 degrees or more it is said that the rolled-up, cord-like quadriceps tendon gives the guide as to which the direction of rotation has been—inward or outward. This is to be determined according to whether the anterior edge above the patella is continuous with the outer or the inner border of the quadriceps muscle.

held in extension. If the patella lies on edge, it is firmly held by muscle tension. It may be possible to distinguish by touch between the articular surface and the flat front surface.* If this sign is not available, the lifted edge of the quadriceps tendon serves to tell in which direction the rotation has occurred. Moreover, the relative ease of rotation in one or the other direction on gentle attempts to reduce rotation will be of assistance.

If the rotation has been total or nearly so, the quadriceps is twisted to a cord, but may still show a guiding edge. This palpable edge may be of help, for rotation is oftener *nearly* complete than complete, and

* I have not seen this lesion, but it seems to me that there must be a dimpling of the skin corresponding to the front surface, owing to the close connections of patella, fascia, and skin. This is not usually given as a sign, however. (See Fig. 894.) Since this note was written, a case of the sort was reduced at the City Hospital Relief Station. Drs. L. B. Packard and E. L. Drowne, who handled the case, both assure me on question that there was a distinct dragging inward of the skin attached to the *front* surface.

is apparently never beyond 180 degrees. Therefore, a quadriceps tendon prominent at (*a*) must mean that the patella has rotated out,—in the direction of the arrow,—not inward. (See Fig. 895.)

Reduction. Reduction is attempted with the knee extended or hyperextended, the leg raised to a right angle with the body to relax the rectus femoris; the actual reduction is by forcible rotation applied with thumb and fingers to the patella.

In some few cases slight flexion has proved a more favorable position than extension for such manipulation. The patella is very firmly held, and reduction may be very difficult. Hooks have been used, and tenotomy resorted to. Today, obviously, open operation would be the choice if simple attempts at reduction fail.

CONGENITAL OR HEREDITARY LUXATION

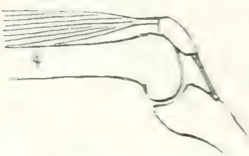
Bogen * describes a series of cases that justify his assumption of a class of really hereditary outward luxations of the patella, some of them actually congenital, some associated, like the upward luxations with genu recurvatum, with failure of development of the patella.

* Zeit. f. Orthop. Chir., xvi, Hft. 3, 4.

CHAPTER XXVI

FRACTURE OF THE PATELLA

Fracture of the patella is common, occurring predominantly in male adults in the vigorous years. It is not rare in women, but is a rare injury in children.



[illegible] the *curved* surface of the condyles by the contraction of the [illegible] the upper end of the patella. [illegible]

Patella fractures are divisible into two classes: (1) Transverse; (2) vertical or irregular or comminuted.

Either variety may be compound—not very infrequently.

TRANSVERSE FRACTURES

The transverse fractures are nearly, *if not quite*, always the result of muscle action, most often of that sudden, very powerful muscle action exerted to save one's self from a fall.

With the knee bent at say 60 to 90 degrees, the patella is held by the ligamentum patellæ firmly down and against the condyles, while the full pull of the strongest muscle in the body is suddenly exerted at its insertion on the top of the patella, well out of line with the fulcrum (*i. e.*, the convexity of the condyles) (Fig. 896), and the result is a fracture, approximately transverse, at or about the part of the bone resting on the fulcrum.

[illegible] less [illegible] the break in the pa- [illegible] the capsule at the lateral expansion of [illegible] quadriceps on either side of the joint.

But this is not all, or the most important part: the force continues to act, and the lateral expansions of the quadriceps tendon—in which the breaking patella has started a rent—tear widely out to either side: the whole extensor apparatus is gone, and there is no hindrance left to oppose separation of the patellar fragments. The tears vary in extent, but it may be laid down as a rule that fractures by muscle violence (including nearly all transverse fractures) show this tearing and show separation of fragments. The importance of this as to treatment we shall come to later.

IRREGULAR OR COMMINUTED FRACTURES

The other class, the irregular fractures, result from direct trauma, usually in falls. Rarely, the impact of the fall, caused by the bone giving

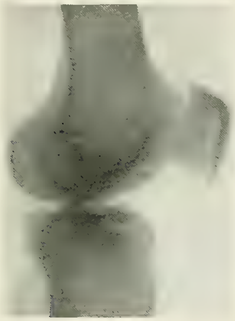


Fig. 898.—Normal x-ray profile of the knee, showing very well the straight-back surface of the patella and the curved surface of the condyles.

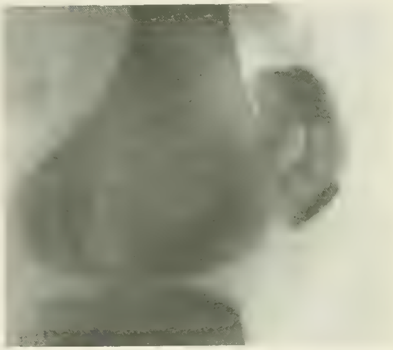


Fig. 899.—Direct violence, three fragments, no tearing of the capsule; no operation (writer's case).

way transversely, may in turn result in comminution of fragments, but as a rule we have definitely *one or the other type.*

Whatever the lines of the irregular fracture, we have substantially no separation of fragments. The shivering of the patella by a blow gives no cause or starting-point for a tear of the ligament at the sides.

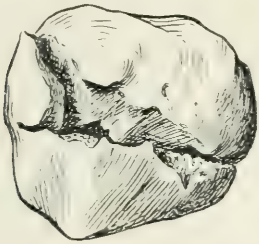


Fig. 900.—Recent fracture of patella, with comminution. From direct violence (Warren Museum, specimen 1130).

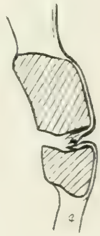


Fig. 901.—Periosteum and tendon-shreds in quantity fall in between the broken surfaces from the front.

It is not uncommon to hear patients ascribe a broken patella to the fall as such; of course, there is a fall in either case, but I believe these stories to be due to error in observation; at all events, I have seen no cases in which there seemed to be any doubt in judging from the lesions as to the mechanism of their production.

Lesions

We have a clean-cut, pretty regular fracture-line *in the first class of cases:* it runs from cartilage to periosteum, without any considerable irregularities, almost exactly at right angles to the long axis of the bone, usually nearer the bottom than the top. The periosteal and fascial coverings of the bone in front are torn into ragged ends, which fall between the fragments, often largely covering the broken surfaces, and promptly adhering to them. The patellar fragments are apt to rotate forward or back, often through 60 to or sometimes even through 90 degrees; they retain this position (as they take it) without obvious cause.

Fig. 902.—Much tilting of fragments is not unusual, often without evident cause, and, as in this case, in spite of careful non-operative treatment.

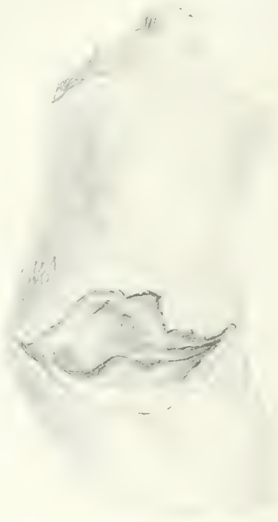


Fig. 903.—Compound fracture of the patella from refracture through the old adherent subcutaneous scar of the first fracture (drawn from the plate in Bell's Surgery, vol. ii, Plate III).

Fig. 904.—Patellar fracture from indirect violence; slight separation of fragments.

The torn edges of the capsule lie separated only by blood-clots.

Separation of both bone and capsule fragments is apt to be slight, until bleeding and serous effusion distend the joint.

Bleeding into the joint, and outside the joint into the torn and bruised tissues, is usually considerable in amount.

The fracture may be *compound* as a result of the secondary fall, or any adherent scar (*e. g.*, from a previous operation for patellar suture) may determine a simple tearing open of the skin above the fracture, so that the joint lies open. (See Fig. 903.) Any form of compound fracture is relatively rare.

Lesions in class 2 from *direct* violence differ in that the fracture lines are irregular and may be ragged. There is *no* tearing of the capsule at the sides, and little tearing of the structures in front of the knee-pan. There is no dropping in of torn shreds between bone-fragments in this type of fracture.

Separation of fragments is very slight at most—it is prevented by the strong intact tendon in which the patella still lies as a sesamoid.

This form may also be compound, and is *more often compound than the fracture by muscle-pull.*

Lesions beyond those described do not belong to the fracture of the patella as such. Injuries to vessels, nerves, etc., are conspicuous by their absence in all patellar fractures, for no great nerve-trunks lie near the front of the knee.

Symptoms

"Can a man with a fractured patella walk?" This is a favorite examiner's question. The answer is that he can! In the books he walks backward. The only patient I recall who walked after fracture with a complete transverse tear said he did not walk backward, but, as near as he could tell it, *swung* his leg forward and locked it in hyperextension before putting his weight on it, as do so many cripples from old infantile paralysis.

Of course, if a man has an intact tendon and a splintered patella within it, so to speak, there is no *mechanical* reason why he should not walk, even without resorting to hyperextension.

As a matter of fact, he *does not* walk with any type of fracture, because it hurts. Nor does he lift the foot as he lies on his back because it hurts: if he has a torn capsule, he *cannot* do it, not only because of pain, but also for *mechanical* reasons.

He has also a good deal of pain, and when the effusion is fairly established, at twelve to twenty-four hours, he has much pain, and may even have a little temperature.

Diagnosis

Type I (Transverse).—Diagnosis depends on: (*a*) Loss of active extension: he cannot raise the foot from the bed as he lies on his back, and cannot voluntarily straighten the flexed knee.

(*b*) A rounded swelling of the whole joint, differing from simple synovitis in that it is evenly rounded.* There is often much ecchymosis and swelling *about* the joint.

(*c*) The fragments may be palpable—are palpable, as a rule, despite

* The difference between such effusion and the common synovitis is sketched in Fig. 905. It seems no exaggeration to say that such a *rounded* effusion must mean either patellar fracture with separation, or rupture of the quadriceps or of the patellar tendon. I have seen no exception in several years' observation of this particular sign.

the swelling, and their mobility and the interval between them may usually be demonstrated.

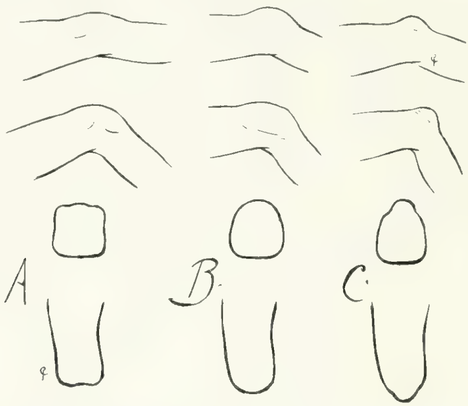


Fig. 905.—In synovitis (A) there is moderate swelling, seen from the side; on flexion, this becomes a bulging, especially pronounced at the sides of the joint, between quadriceps tendon and ligamentum patellæ and the iliotibial band, and at a corresponding point to the inside. The thigh, seen from above (knee flexed), shows *lateral* bulging, as in the lowest figure. Cross-section would show *lateral* bulging; in the center the extensor tendon and the patella hold down the bulging. If the patella is broken, there is no such resistance. We have an even, *globular* swelling of the whole joint (B). Fluid in, or hemorrhage into, the prepatellar bursa gives the condition shown at C, an added lump in front of the patella, not modifying the shape of the knee.

Fig. 906.—Patellar fracture (fresh). Note the even, rounded swelling.

(*d*) There may be crepitus, but often it is felt only after forcibly

dragging the fragments together. If there is much effusion, crepitus is not obtainable.

Diagnosis of Type 2 (Irregular).—Diagnosis depends on: Pain and loss of function; tenderness—localized; mobility of fragments; interval (a line only) between fragments; crepitus.

Synovitis in this type is almost constant, but the effusion rarely reaches such amount as with type 1. Moreover, the especial appearance above noted—the domelike rounded swelling—is absent; the outline is like that of any acute synovitis, for there is practically no separation of the fragments of the patella.

Differential Diagnosis of Patella Fracture.—Differential diagnosis

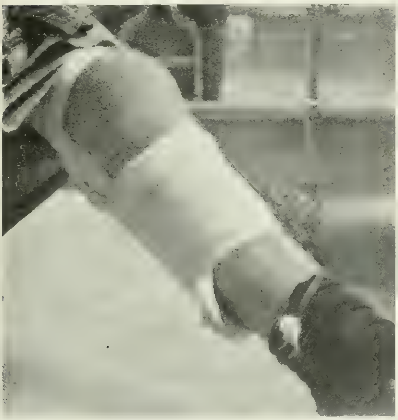


Fig. 907.—Patellar fracture, with separation of fragments, after some days. Note even, globular swelling of whole joint.

Fig. 908.—Synovitis (subacute) of right knee. Note the bulging at the sides of the joint, limited by the quadriceps, patella, and ligamentum patellæ in the middle line.

concerns especially quadriceps rupture and rupture of the ligamentum patellæ, or tearing out of its insertion.

Both give loss of extensor power; both give, in a measure, the *rounded* swollen joint. The downward mobility, and the readily palpable gap *above* the patella distinguish the one; upward mobility (and dislocation) of the patella and the signs of damage farther down, well *below* the knee-pan, characterize the other.

In diagnosis it may be well to recall that irregularity counterfeiting a gap in the bone, and a crepitus of a sort, may both belong to a dry bursitis of the prepatellar bursa. Twice within the half year past have I seen such cases classed as patellar fracture.

Treatment of Patella Fractures

The many minds of many men have been curiously displayed in the literature on treatment of patellar fractures, particularly in regard to

operative treatment. This literature is historically very interesting, but surgically all the discussion is much out of date.

The facts seem clear.

We have, on one side, the results of non-operative treatment, safe, but usually imperfect and unsatisfactory; on the other hand, the operative results, brilliant, but not without risk.

The risk of operation is sepsis.

Many years ago Lister advocated wiring, as did others after him.

Wiring, as then done, was clever, but hardly safe enough.

Today we have a better technic, and far less danger is involved.

Conservative treatment offers the *safe* prospect of a knee that will be useful after six to twelve months, for light work at least.

The chance of a *perfect* result under such treatment is practically nil, though many *serviceable* knees have been obtained by such treatment.

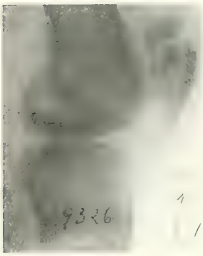


Fig. 909.—Direct violence; no displacement; no tearing; no operation.

On the other hand, we have the results obtainable by operation: the possibility of a *perfect* result, obtainable in half the time required for splint treatment.

But this treatment calls for the opening of the largest joint in the

Fig. 910.—Unless bony contact is perfect, the presence of joint fluid hinders callus formation, and the fibrous bond is *less* in depth than the depth of the bone.

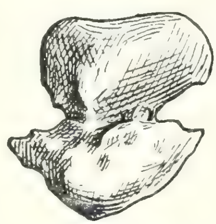


Fig. 911.—Fracture of patella; fibrous union. Broadening of lower fragment (Warren Museum, specimen 3652).

Fig. 912.—Fracture of patella. Fibrous union with moderate separation; no enlargement of fragments. View from side: *a*, Fibrous union; *b*, extent of articular surface which is now concave (Warren Museum, specimen 1129).

body, a joint notoriously hard to deal with, and it carries a risk of sepsis that we cannot honestly ignore.

The risk is statistically very small in recent years, but we must all admit that cases of sepsis, even cases of death from sepsis, have resulted, even in the hands of competent surgeons, from such an operation.

The question of operative treatment is one on which we must advise

the patient according to his years, his condition, and the needs of the occupation by which he earns a living.

We may tell the patient how long he must wait for a *doubtful result* without operation, and may tell him of the quick, clean results obtained by operation.

We may *not*, however, *force* an acceptance of operation unless we can show less risk than has obtained in the past from this operation.

Surgically, the question may be considered as follows:

Fracture of the patella without separation of fragments (*i. e.*, the cases from *direct* trauma) do well under *any* treatment (or no treatment).

Fig. 913.—Fracture of patella; union with long fibrous band (Warren Museum, specimen 5253).

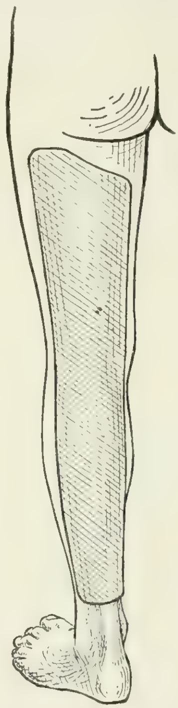


Fig. 914.—Ham-splint without strap, showing proper length and relation to thigh and leg posteriorly.

Fractures with separation under conservative treatment *never unite by bone;* never show obliteration of the gap between fragments. Consequently, there must be a bond of fibrous tissue—a bond, in all instances, of less thickness than that of the patella (Fig. 910). If this bond be short and firm, *and remain so*, the knee may be practically as useful as ever. But if the fragments are widely separated before union commences, *or* if the bond of union stretches with use, we have, as an end-

result, a lengthened tendon *without a sesamoid* (see Fig. 913), and consequently a weak and unreliable joint, as a rule.

A union giving a rigid but *long* patella often gives poor motion, as Chaput has noted, mainly because of limited motion. (See Fig. 915.)

Fig. 915.—Fracture of patella; bony union; some elongation of bone as a whole. View from side (Warren Museum, specimen 6707). This bone is too long for *good* function as a sesamoid.

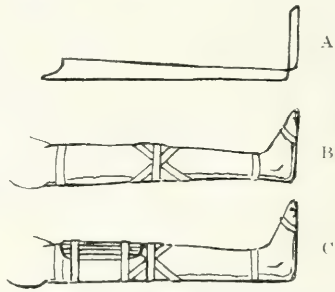


Fig. 916.—Splint treatment: A, Posterior wire splint; B, leg strapped to splint; patellar fragments strapped down with adhesive-plaster strips; C, coaptation splint to front of thigh; a bandage finishes the dressing.

Final union is very late in all these non-operated cases, and function is almost always imperfect.

In operated cases, on the other hand, properly handled, we are sure of union, usually bony; at worst we get a *short* fibrous union, with *early* restoration of function. (See Fig. 917.)

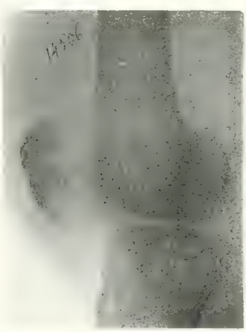


Fig. 917.—Old patella fracture. Sutured at time of accident. Close fibrous, *not bony*, union. Excellent, practically perfect, result clinically.

The two methods of treatment, discarding unnecessary discussion and detail, may be described as follows:

Non-operative Treatment.—Pad a "posterior wire" splint. (See Fig. 916.) Strap the leg to it. Raise splint (and leg) on pillows. (This is to relax the rectus femoris.) Apply coaptation splints to the front of the thigh, over the quadriceps muscle, to insure its relaxation. Strap the fragments as shown in Fig. 916. Keep up the treatment for six to eight weeks; then get the patient up on crutches, with a protecting ham-splint or light plaster. Begin massage at about six to eight weeks, with *very gentle passive motion.* Do not begin weight-bearing under three to four months, and then without flexion. *Active motion and use of the joint begin at six months.*

Operative Treatment.*—Aseptic preparation should be most scrupulous. Cut on the line shown in Fig. 918, to avoid thickened skin, and

* All operative procedures in this as in other fractures are safest at or after ten days. By this time organization of clot minimizes the chance of sepsis.

to keep the scar away from the kneeling surface. Clean out all old blood-clot from the joint by picking and washing. Clear the fractured surfaces of periosteum, etc., that has dropped down between the fragments. Pick up the periosteal capsular layer at either side of the patella, and suture it snugly with kangaroo tendon.* (See Fig. 919.) Suture the lateral tears of the capsule with catgut. Put the knee up in hyperextension in plaster, *without* drainage.

Under proper conditions and technic, septic accidents are very rare. On the whole, the operative treatment has decidedly the best of the argument.

One argument, of no small importance in urging us toward operation, is that the earlier useful results in operated cases save many men to usefulness who would *degenerate* under conservative treatment.†

Fig. 918.—Line of incision of choice; above the coarse skin of the friction surface in the region of the patella, and above the fracture, with the least chance of tearing the joint open if there is refracture. Moreover, the scar of the wound here shown is subject to *no* pressure.

Fig. 919.—Best plan of suture. Mattress sutures of heavy kangaroo-tendon at either side of the patella; accessory sutures for the lateral capsule tear (practically J. A. Blake's operation).

After-treatment

In cases operated, as well as those treated without operation, the first chance to be guarded against is refracture.

This may occur in either case. It may best be guarded against by massage and careful passive motion.

The chance of refracture is greatest in the relatively rigid knee.

If treatment has already secured 30 to 60 degrees of flexion, the chance of refracture is slight, even if the patient makes a misstep or stumbles.

Refracture with giving way of the suture is more apt to happen with wire than with the more elastic kangaroo tendon.

* Absorbable sutures are as reliable as the old-fashioned wire, and on the whole, *less* likely to break. They last as long as we need them.

† Those of us who see and follow up many cases of trauma in the larger metropolitan hospitals come to realize that the average "workingman"—the man most subject to traumata—works more from habit and necessity than from conviction. The difference between a treatment that promises results within two to three months and one that calls for a year of idleness may often mean the difference between a useful citizen and a park-bench loafer. Such a difference may well justify the taking of some slight additional surgical risk. In the last analysis we may better subject a man to the chance of sepsis than to the influence of the 15-cent lodging-house.

If such "refracture" occurs, immobilization will minimize the damage and will give reasonably prompt results, comparable to the *best* results of non-operative treatment, *without* a fresh operation.

Fig. 920.—Old patella fracture, not operated. Note the great increase in the *total* mass of the patella.

Refracture after eight weeks is rare.

If wire has been used and has broken away, even without appreciable

Fig. 921.—Old patella fracture, not operated on. Great separation. Nodules of bone formed in the fibrous band of union.

Fig. 922.—Old patella fracture, not operated.

separation of fragments, the removal of the wire is often called for later on account of irritation. Such removal through a small incision theoreti-

cally involves opening of the joint, but, in fact, is a simple procedure, almost devoid of risk. At times the wire causes irritation later, and calls for removal, even though it has not broken.

The *second* thing we have to look out for is stiffness. In the cases operated on we can begin careful massage and passive motion (temporarily removing apparatus) at three weeks. In unoperated cases we usually wait for six to eight weeks.

In either case serious loss of motion is very rare indeed; even neglected cases, kept fixed for months, get good motion.

At times I have found it of use in operated cases to hurry things up by manipulation under ether at eight to ten weeks. This, however, is to be done with great caution, not to risk refracture.*

OLD FRACTURES OF THE PATELLA

Old fractures of the patella unoperated almost always show some separation of fragments. Separation of fragments is not an indication for operation. Operation is called for only to improve poor *function*.

Fig. 923.—In cases operated so long after injury that the muscles have shortened the quadriceps may be lengthened by alternate cuts, right and left, so as to permit suture of the patella.

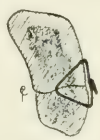


Fig. 924.—If we *must* use direct wire or suture, it is passed as here shown; it *must not* lie in the joint at any point.

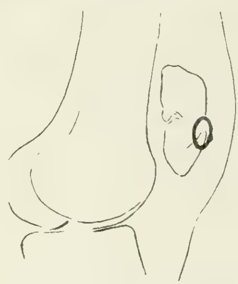


Fig. 925.— Patella fracture. Wired. Bony union.

The main difference between these late operations and the early ones is that there is a shortening of the quadriceps muscle, as well as a separation of fragments. Often the separation may be overcome by simple traction and suture. At times we cannot bring the fragments together without lengthening the quadriceps tendon. (See Fig. 923.)

In these old cases, and these alone, the inelastic rigidity of a wire suture is of advantage.

In such old cases, owing to muscle shortening, the return of motion in flexion is slower and less perfect than in cases operated shortly after injury. Useful results are the rule, perfect joints the exception.

* One case has come to my notice in which there was such refracture from manipulation "to break up adhesions," after four weeks.

RUPTURE OF THE QUADRICEPS TENDON

This rupture occurs only from muscle action, and is a sort of equivalent of fracture of the patella. The symptoms are the same, the physical signs the same, save that instead of an interval between fragments, we find an abnormal hollow—a gap—*just above* the patella.

The extent of damage varies. There may be an incomplete tear, giving nearly entire loss of function and a palpable gap, but tending to prompt repair. I have seen two such cases that recovered entirely in a few weeks under simple splinting.

The tear is usually a tearing out of the *insertion* from the patella, but may be a tear of the tendon proper.

Where the tear is complete and involves the capsule at the sides, the disability is as absolute as in patellar fracture, the tendency to spontaneous repair far less. I have seen two cases, not operated on, in which, after many months, there was absolutely no power of extension. The gap that had developed in one case was about three inches.

Operation, consisting of a simple suturing of torn ends or of the one torn end to the periosteum of the patella from which it was torn, gives entirely satisfactory results.*

RUPTURE OF THE LIGAMENTUM PATELLÆ

This is a rare accident—rarer than quadriceps rupture. It occurs as a result of muscle pull. The ligament is torn across or torn away from the patella, or torn away from its insertion, sometimes fetching with it a scale of bone. The symptoms are those of fracture of the patella.

Examination shows a gap below the knee-pan. There may or may not be obvious upward luxation of the patella. Sometimes enough of the lateral expansion is left to hold the patella down. Displacement seems never very great.

Diagnosis is based on: (1) Local pain and tenderness; (2) inability to extend the leg actively, in the absence of any hindrance to passive extension; (3) palpation of a gap, or, at all events, a loss of the firm outline of the normal tendon.

Treatment by splints and strapping is not satisfactory. Open suture gives practically perfect results in cases reported.†

* I have operated on but one case, with excellent result. The operation in the hands of others seems to have been uniformly successful, barring accidents. The suturing of tendon to patella is difficult, and calls for patience. If the periosteum is insufficient, we may pass the kangaroo-tendon suture through the top edge of the bone (two drill holes) and through the end of the tendon, as a mattress suture. This I had to do in the case cited.

† I have operated on but three cases, with excellent result. In one there was a clean rupture; in the others no clean tear, but a lengthening of the tendon by pull-

AVULSION OF THE TIBIAL TUBERCLE

Tearing off of this tubercle as a chip of bone may occur at any age as a result of muscle pull, but it is rare in adults. It is diagnosed by the presence of a loose chip of bone; it is treated by a splint and by strapping—by pegging the fragment down if there is a marked displacement to be dealt with. The lesion is a result of single trauma—an equivalent to rupture of the tendon.

The results seem to have been very good in cases recorded.*

In youths and children the equivalent of this accident is not uncommon,† but the cases present themselves as the result, not often of a single trauma, but rather of a recurring lameness from overstrain, sometimes giving a history of the *first* trouble having been the result of football scrimmages or the like.

Fig. 926.—Traumatic separation of the end of the tongue of the tibial epiphysis at the tuberosity (compare Figs. 933–937).

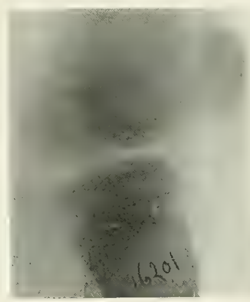


Fig. 927.—Similar case to that of Fig. 926, in which the separated fragment is barely shown as a small faint shadow at the point of insertion of the ligamentum patellæ. In both this and the preceding case this loose fragment had to be removed before relief was obtained.

To understand this lesion we must look into the anatomy. In childhood the tibial tubercle is cartilaginous. Sometimes it is a part of the main epiphysis, from which a long tongue runs down (see Figs. 933 to 935); sometimes there is a separate epiphysis, and sometimes this part is separate, but consists of cartilage without a demonstrable ossification center. This cartilaginous tubercle receives a *part* of the insertion

ing apart of fibers. In these cases the tendon was cut and shortened by overlapping.

It may be noted that neither the trauma nor the operation *necessarily* involves opening of the knee-joint, though usually it is torn into.

* Sendler, Deutsche Ztschr. f. Chir., 1893, xxxvi, 546. Godlee, Illust. Med. News, September 29, 1888, vol. i, p. 12.

† Jacobsthal, Deutsche Zeit. f. Chir., 1906–07, vol. lxxxvi, p. 493 (with full literature references); Osgood, Boston Med. and Surg. Jour., January 29, 1905; Makins, Lancet, 1905, ii, 213.

of the ligamentum patellæ not all of it. Consequently it is not liable to be torn off bodily, but may be loosened from its bed by single or repeated violent contractions of the quadriceps. So long as the leg is used it does not quiet down into its bed again.

Symptoms consist of lameness in the knee on severe use, usually sharply localized, but sometimes with recurring synovitis as well.

Diagnosis depends on lameness, slight thickening, local tenderness, and on the palpation of a slightly movable small fragment. The x-ray shows some widening of the epiphyseal line; sometimes it shows an obvious lifting-off of the tubercle; sometimes it shows nothing.

Treatment.—Some cases quiet down with rest, and under simple adhesive strapping running across the leg over the loose fragment. The fragment presently becomes fixed in place. In other cases this does not work.

The writer has had excellent success in cutting down on the fragment and removing both it and the "false bursa" that sometimes forms under it. In this operation the joint is not opened, the ligamentum patellæ is not damaged,—merely split,—and use of the leg can be resumed in two or three weeks.

Prognosis.—Untreated, these cases go on for a good while, giving much lameness. Properly treated, they do well and give a perfectly functioning knee. There is no interference with subsequent growth from trouble with this small epiphyseal fragment, whether the lesion is treated or not.

CHAPTER XXVII

TIBIAL INJURIES JUST BELOW THE KNEE

A variety of fractures occur in this region, both from direct smashing violence and from indirect trauma. There may be a cross-break, or a T-fracture, or a splitting-off of either tuberosity as a whole or in part.

Fig. 928.—Same as Fig. 929, from the front. Shows how the external popliteal winds around the head of the fibula and becomes separated into peroneal and anterior tibial supply.

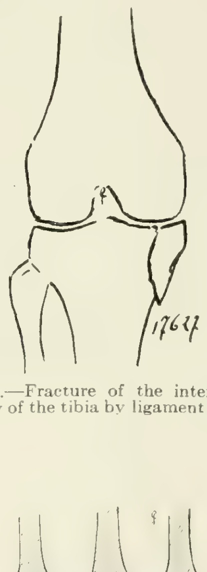


Fig. 930.—Fracture of the internal tuberosity of the tibia by ligament strain.

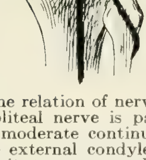


Fig. 929.—The relation of nerves to bone behind. The external popliteal nerve is particularly subject to violence or to moderate continued pressure in its course behind the external condyle and the tibia to the point where it turns around the neck of the fibula. In this latter region it is pretty firmly bound down, and stretching injuries as well as pressure injuries are to be looked for.

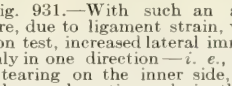


Fig. 931.—With such an avulsion fracture, due to ligament strain, we shall find, on test, increased lateral immoblity, but only in one direction—*i. e.*, if there be a tearing on the inner side, we will have abnormal motion only in the direction of abduction.

Displacement is apt to be by gravity. If there is a T-fracture, or if only one tuberosity is broken, there is usually widening just below the joint. In any case there is abnormal mobility laterally,—either

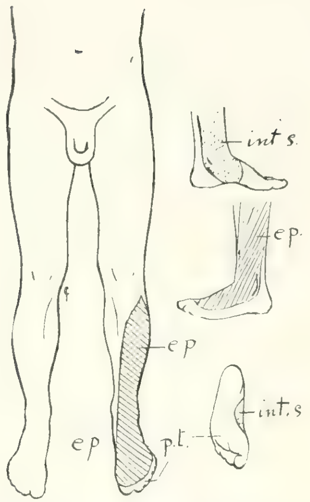


Fig. 932.—The skin supply corresponding to the various nerves of the leg and foot: *int. s.*, *int. s.*, Internal saphenous; *e. p.*, *e. p.*, *e. p.*, external popliteal; *p. t.*, posterior tibial. The areas of anesthesia or paresthesia in leg injuries give us definite information as to the nerves injured; unfortunately, however, many of the most obstinate injuries, particularly of the external popliteal nerve, are almost entirely motor in character, and may very readily be overlooked for a long time.

Fig. 933.—Another view of same specimen as shown in Fig. 935.

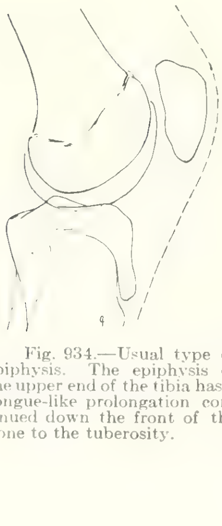


Fig. 934.—Usual type of epiphysis. The epiphysis of the upper end of the tibia has a tongue-like prolongation continued down the front of the bone to the tuberosity.

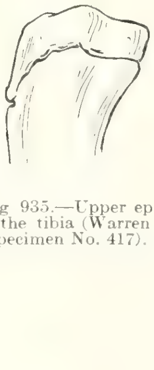


Fig 935.—Upper epiphysis of the tibia (Warren Museum, specimen No. 417).

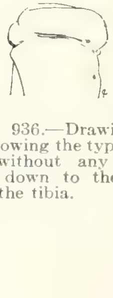


Fig. 936.—Drawing from x-ray, showing the type of epiphysis without any tongue running down to the tuberosity of the tibia.

way in a cross-break or a T-fracture or epiphyseal separation,—but limited to motion one way only if only one tuberosity is broken.

Diagnosis rests on local swelling and tenderness, on widening, on the lateral mobility, and on crepitus. Sometimes the broken fragments may be made out clearly by palpation while an assistant manipulates the leg, but by no means always is this the case. The x-ray is often essential.

Replacement is by traction, by manipulation to correct backward displacement, by lateral "jamming" of fragments together, whether there is a T-fracture or a break on one side alone.

Retention is by plaster, with adequate felt padding. Permanent

Fig. 937.—x-Ray showing same type as in last figure.

traction in the axis of the leg does no harm at worst, and may be of definite value. Such traction may well be combined with the plaster cast.

Any tendency to displacement is due not to muscle pull, but to gravity. Backward bowing is common, and carefully to be guarded against by frequent inspection and revision of padding.

Results are fair—union is prompt, but with a good deal of thickening, and usually some loss of motion at the knee results.

Damage to the external popliteal nerve is not very uncommon. Fig. 929 shows how exposed it is to trauma at this level.

SEPARATION OF THE UPPER EPIPHYSIS OF THE TIBIA

This is one of the rarest of epiphyseal separations, and data are scanty. Displacement may be in any direction. Diagnosis is based on the signs

of fracture in the given location, with only *soft* crepitus, at the appropriate age.

Reduction is by traction, rocking, and direct pressure.

Prognosis, given the proper reduction, is good.

There seems to be no special liability to damage of vessels or nerves.

Interference with growth is not to be expected.

Avulsion lesions of the tibial tubercle are treated on p. 527.

CHAPTER XXVIII

THE FIBULA

LUXATION OF THE UPPER END OF THE FIBULA

Luxations of the fibular head are not common, but probably often pass unrecognized.* As to causation, we may divide them into three classes:

(1) *Posterior luxation*, usually caused by muscular traction through the biceps tendon.

(2) *Anterior luxation*, probably from adduction and inward torsion (with the knee in extension), resulting in rupture of the long external lateral ligament.

(3) *Upward luxation*, from *upward thrust* on the fibula exerted at the ankle (abduction of the foot), with or without associated ankle fracture.

This luxation is really only a complication of the ankle injury.

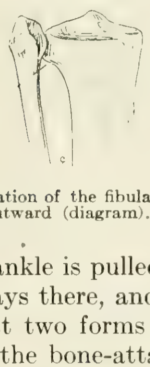


Fig. 938.—Luxation of the fibula upward and outward (diagram).

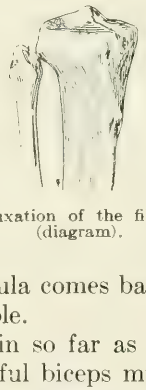


Fig. 939. -Luxation of the fibula backward (diagram).

When the ankle is pulled back in place, the fibula comes back where it belongs, stays there, and gives no special trouble.

The first two forms are troublesome only in so far as the fibrous support of the bone-attachments of the powerful biceps muscle, or of the equally important external lateral ligaments, is rendered less firm. The fresh injury gives much pain and disability. Synovitis of the knee may follow it

Diagnosis in these cases is not easy. There is extreme local tenderness. The fibular head may be, but oftener is not, abnormally movable.

* Golley (Amer. Jour. Surg., 1907, xxi, p. 171) records a case and reckons the reported cases as about 25. His case was a forward and outward luxation. Stimson gives a like estimate. Probably this is far too small, as the injury is a minor one, and probably the mass of cases are never reported, even if recognized. I have seen but one case, and have personal knowledge of but one more, both backward luxations.

Measurement from the tibial tubercle to the fibular head is our best evidence. The x-ray *may* help.

Reduction is nearly useless, inasmuch as the joint is a flat joint, and the muscle pull, at least in the backward displacements, is constant, and sure to reproduce at least partial displacement.

Treatment consists in immobilization for several weeks. Flexion to relax the biceps is indicated in the backward displacement.

Prognosis is good as to general usefulness of the limb. There may be, however, a little weakness referred to this region—a weakness mainly due to the strain exerted through the attachment of the biceps.

Two cases of this partial disability have come to my notice.

Apparently no one has attempted operative treatment of the cases, but an attempt to promote short fibrous (or even bony) union at this joint would seem rational.

FIBULA FRACTURE NEAR THE HEAD

Fractures of the head* or neck of the fibula are rare. They may occur with fracture of the tibia much lower down, or independently from torsion, from muscle traction, or from a direct blow *without* tibia fracture.

Their importance is almost solely due to the fact that the peroneal nerve winds about the neck of the fibula, and is here much exposed to trauma in fractures from indirect force, as well as those from direct blows (Figs. 928, 929).

The fracture is diagnosed by tenderness, crepitus, and the x-ray. The nerve lesion shows itself in toe-drop: loss of sensation is not usual.

Treatment is by immobilization: persistent displacement is rare and not worth considering, except for nerve-pressure.

Operation to free the nerve is amply justified in any doubtful case, but is unnecessary in most cases.

* Stimson and Weir (see also Poland) have recorded cases in which epiphyseal separation took the place of the fracture.

CHAPTER XXIX

THE ANKLE AND FOOT

LANDMARKS OF THE FOOT AND ANKLE

The most prominent landmarks are the two malleoli. The internal malleolus is palpable over its whole surface in most individuals. In cases of injury, however, with swelling, the lowest point we feel is the slight ridge that lies distinctly *above the tip* of the malleolus. The front edge of the malleolus may also be made out, and usually the ridge at the back. The external malleolus always shows a recognizable ridge at its back edge, and a ridge, often spur-like at one point, at the front of its subcutaneous surface. The end of the external malleolus

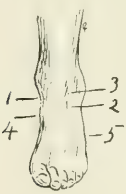


Fig. 940.—Landmarks of the ankle from the front: 1, Tip of internal malleolus; 2, outer side of head of astragalus (just outside and below this is the deep hollow of the sinus tarsi); 3, the outer edge of the upper articular surface of the astragalus, best felt with the foot in plantar flexion; 4, tubercle of scaphoid; 5, prominence of the base of the fifth metatarsal.

Fig. 941. — Landmarks from the inner side: *a*, Internal malleolus; *x*, sharp tip of internal malleolus, not always to be felt; *y*, tubercle of scaphoid. A comparison of the measurement *a–y* on the sound and injured foot is often serviceable in the diagnosis of the various injuries of the ankle.

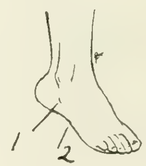


Fig. 942.—Landmarks from the outer side: 1, Peroneal tubercle, always palpable, often prominent; 2, prominent base of the fifth metacarpal.

is always to be felt as a bony surface, though it may not be possible to reach the extreme tip. What we can feel of the astragalus is, in the first place, the outer edge of the head, to be felt for as shown in Fig. 940, and an equally valuable though often neglected landmark, consisting of the smooth sharp edge of its upper articular surface, is to be felt just in front of the fibula, and recognized in distinction from the fibula by putting one hand on the external malleolus, the other on this ridge, and moving the ankle up and down. Motion between the two is readily made out. Sometimes it is possible to feel the inner side of the neck of the astragalus, and to grasp the neck between the thumb and finger. The inner side of the head is practically covered by the scaphoid.

The os calcis shows no palpable points on its inner surface, except

at the very back. At the back the two vertical planes to the inner and outer side may be felt, and their direction roughly estimated (Fig. 945). The outer surface of the os calcis is palpable and practically subcutaneous. The peroneal tubercle may usually be felt just below the external malleolus (Fig. 942).

The scaphoid is always to be made out, and is the only prominent rounded mass on the inner side of the foot (Fig. 941). In its normal position it occupies a point in prolongation of the line of the front of the tibia (Fig. 943). This landmark the writer has tested in a great

Fig. 943.—From the inner side, a line running through any two points on the tibial crest prolonged downward just about strikes the scaphoid tubercle. It makes little difference for this test whether the foot is flexed or extended.

Fig. 944.—The best measurement of the length of the foot is from the end of the great toe to the posterior convexity of the heel, as shown. This should be a straight line measurement, not following the surfaces. Owing to the firmness of the tissues, acute swelling makes very little difference to this measurement.

Fig. 945.—From behind, the surfaces of the os calcis toward the inner and outer side may be clearly made out by careful palpation; they lie about as shown in the figure.

number of patients, and has found it substantially accurate always, irrespective of the position of the foot as regards flexion or extension.

The cuboid is not normally palpable, except as a resisting surface, nor are the cuneiforms, unless they are displaced.

The base of the first metatarsal may often be made out by its prominent lip on the plantar side.

The base of the fifth metatarsal, always prominent, may also be identified (Fig. 942).

Below this point there are no landmarks that are serviceable in a foot swollen from injury. In injuries to the front part of the foot we are very often dependent upon *shortening*, as shown by lack of corre-

spondence in the length of the foot from the heel to the toes. In general, it may be noted that we should never neglect measurement of the total length of the injured as compared with the sound foot. Normal differences are slight. Shortening due to injury (in whatever portion of the foot) is not accurately appreciable by the eye, but is readily measured. Measurement is made from the tip of the great toe to the back of the heel at its greatest convexity. This, of course, must be a straight-line measurement. It is subject to only slight error, for the heel never swells at the back, but at the sides.

Injuries At and About the Ankle

In all falls on the feet, and in many slips in which the foot is variously twisted, the ankle and foot are subject to damage. More than this,

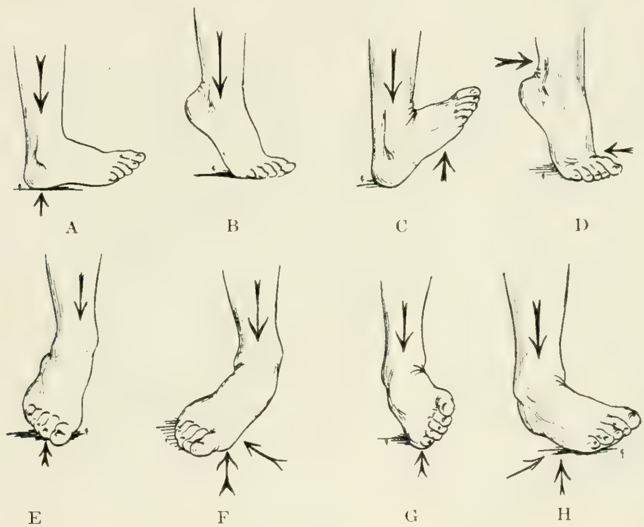


Fig. 946.—Forms of trauma and usual results: A, Ordinarily gives fracture of the os calcis; B, gives either fracture of the neck of the astragalus, or ankle fracture with lateral displacement; C, may give a crushing of the front of the ankle or a fracture above the joint with forward displacement; D, is apt to give one of the forms of subastragaloid or mediotarsal dislocation; E, gives a fracture of the fibula; F, outward rotation (as well as eversion) gives a Pott's fracture or a Pott's fracture with backward displacement and splintering; G, when the weight is received on the front part of the foot, gives only fracture of the fifth metatarsal or sprain of the ankle; H, if internal twist be added to the inversion, produces inverted Pott's fracture, or rarely one of the forms of astragalus dislocation. (The arrows show the line of impact of weight and of resistance.)

direct violence, and indirect violence received by twists of the foot in machinery, etc., are to be reckoned with.

From the history of the accident it is impossible, often, to say whether the resulting damage will prove to be above, at, or below the ankle-joint.

Of lesions to be reckoned with we have the following:

1. Dislocations of the ankle-joint, with and without fracture.
2. Dislocations of the fibula at the ankle.
3. Diastasis of tibia and fibula.
4. *Pott's fracture.*
5. *Pott's fracture with fracture of the posterior edge of the tibia.*
6. *Inverted Pott's fracture.*
7. *Fracture of both bones* above the joint.
8. Epiphyseal separation.
9. *Fracture of the fibula.*
10. *Fracture of the external malleolus.*
11. *Sprains of the ankle.*
12. Dislocation of the astragalus *in toto.*
13. Rotatory luxation of the astragalus.
14. Dislocation of the whole foot beneath the astragalus (subastragaloid).
15. Dislocation of the front foot from the astragalus, with subluxation between calcis and cuboid (medio-tarsal).
16. Fractures of the astragalus—(*a*) body; (*b*) neck.
17. *Fracture of the os calcis.*
18. Luxation of the os calcis.
19. Fracture of the cuboid.
20. Dislocation of metatarsals on the cuneiforms and cuboid.
21. *Fracture of the metatarsals.*

(The lesions more usually presenting themselves are in italics.)

LUXATIONS OF THE ANKLE-JOINT

The common luxation of the ankle is that complicating Pott's fracture, which involves necessarily a subluxation outward and not very infrequently a backward or forward luxation. Inverted Pott's fracture involves subluxation inward.

Uncomplicated luxation at the ankle is rendered extremely difficult by the deep mortise of bone and the strong ligaments but it may, nevertheless, occur without any fracture.

Uncomplicated luxation may occur forward, back, inward, or outward.

All these forms are rare, and luxation is to be looked on merely as an unusual variant result of the forces ordinarily producing the common ankle fractures.

Forward.—Of forward luxations, Stimson lists only 10 in all. The cases I have seen (three) have shown also a fracture of the front edge of the tibia.* (See Fig. 949.)

Dorsal flexion, even pushed to the extreme, is more apt apparently

* This does not include one case of pathological luxation from infective arthritis.

to give fracture than luxation, unless the flexion is associated with some force that drives the foot forward.

Backward.—The listed cases of backward luxation are very few.

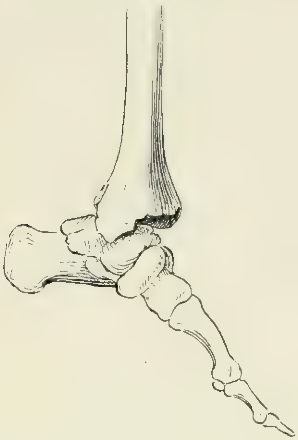


Fig. 947.—Posterior dislocation, with fracture of tibia into joint (also fracture of the fibula) (drawn after A. Cooper's Plate XIX, Fig. 1).

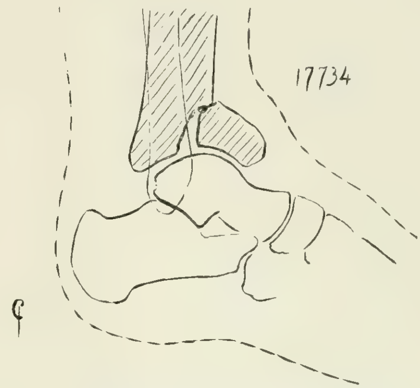


Fig. 948.—Anterior displacement of large fragment split loose from forward edge of tibia, and carried forward with astragalus.

Malgaigne's list was eighteen, probably including, like most of the ancient lists, some fracture luxations, given as simple dislocations.

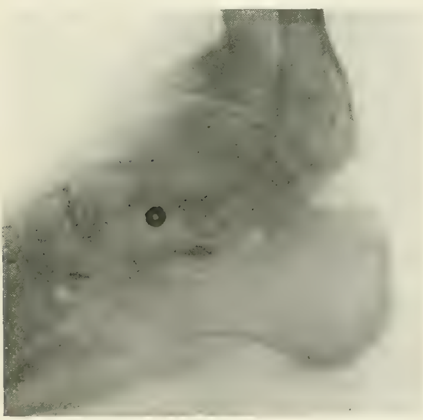


Fig. 949.—Anterior dislocation, with extensive fracture and displacement of the anterior edge of the tibia; also fibula fracture. Old case—about one year after accident (*x*-ray, 19490).

Fig. 950.—Same case as Fig. 949, front view.

Obviously, such luxations backward are favored, if not directly caused, by plantar flexion.

Inward. Inward luxation is about equally rare. It seems from the records that there is a very large range of adduction of the foot associated with these inward dislocations; that is, the luxation is largely by rotation, rather than by inward displacement.

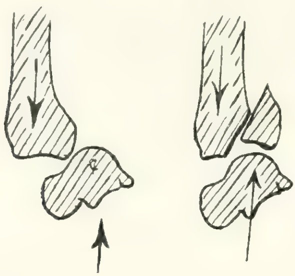


Fig. 951.—Whether the posterior dislocation is accompanied by fracture or not, there is entire loss of bearing surface for the astragalus and nothing to resist progressive deformity until repair is complete. The condition is entirely similar in cases of anterior displacement.

Fig. 952.—In anterior luxation of the foot the projection of the tibia backward is readily palpable. If there is no fracture, the top of the astragalus can be felt in front, but this is obscured by the fragments if the front edge of the tibia is also broken.

Outward. There seem to be no definite data as to *outward* luxation (uncomplicated with fibular fracture).

Backward or forward luxation occurs as a complication of any form of fracture where the structure of the joint mortise is extensively damaged, where ligaments are also much torn. Backward dislocation as a complication of Pott's fracture is not rare. It may occur with typical Pott's fracture, the ligaments being much torn. More ordinarily, however, luxation backward involves a fracture of its own, namely, a splitting-off of the posterior surface of the tibia with the internal malleolus, and fibular fracture is also present. The writer has found this lesion in several cases operated on for deformity years after the accident, and also in fresh cases, where it was demonstrated by the x-ray.*

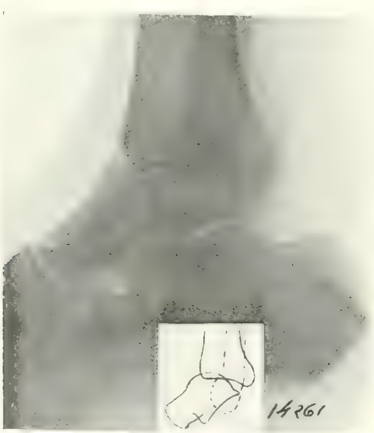


Fig. 953.—Pott's fracture, with anterior displacement of the foot. Displacement of the astragalus forward without fracture of the tibia at the front edge. Fracture of fibula with displacement forward (the small explanatory sketch gives details).

The lesion is serious because the astragalus follows the posterior fragment, and this displacement is apt to result in a broadening from the front to the back of the joint, which

* My impression in regard to these cases is that fracture luxation will be found to be the rule, pure luxation the exception.

results in a loss of dorsal flexion; moreover, the supporting column is weak and is out of proper line (Fig. 951).

In anterior luxation we may find a corresponding fracture of the anterior edge of the tibia.

Anterior luxation, less common, entails a like disability from defective support, to say nothing of the shortened leverage of the tendo Achillis and consequent loss of power. (Figs. 952, 953, 956.)

Diagnosis

Diagnosis of the various luxations is not difficult, except in so far as swelling interferes.

If the scaphoid can be made out, it will be found to lie either forward or back of the line of the tibial crest. (See Fig. 943.)

In backward dislocation the front of the tibia may be felt with a hollow beneath its lower end (Fig. 956).

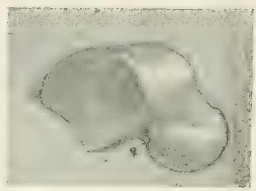


Fig. 954.—Normal astragalus, showing the characteristic shape of the upper articular surface, which has been called the "Saratoga-trunk shape."

In anterior luxation the articular surface of the astragalus may be felt in front of the tibia. Its "Saratoga-trunk" shape is characteristic (Fig. 954). Measurements from either malleolus to the tip of the great toe or to the end of the heel will show shortening or lengthening, characteristic for either type, provided the malleoli are intact (Fig. 955).

In practice, anterior or posterior luxation is obvious to the trained eye or fingers on touch, if not from simple inspection. The outlines (see Fig. 956) are characteristic.

The *lateral* luxations are obvious, the only question is of associated fracture. It is to be recalled that inward luxations involve rotation inward about the *vertical* axis, as well as *inward* displacement. If there is any question of the identification of landmarks, it may be settled by movement of the foot at the ankle. Even if a malleolus is broken, its range of motion is incomparably less on manipulation than that of the normal tarsal bones.

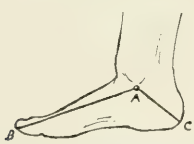


Fig. 955.—Measurement from internal malleolus (A) to the great toe (B) and to the heel (C) respectively, may be very useful, but is, of course, useless if the malleolus itself is damaged.

Fig. 956.—Diagram of outlines in posterior and anterior dislocations respectively.

Reduction

Reduction of anterior luxations is by direct shove backward (see Fig. 957), the foot being in plantar flexion to slacken the tendo Achillis.

Fig. 957.—Manœuver for reduction of anterior dislocation. The foot, carried into moderate plantar flexion, is thrust down and backward while the leg is pulled forward to give resistance.

Backward luxation is best reduced by the grip shown in Fig. 958, the foot being held in moderate plantar flexion.

Lateral luxations are best reduced by traction and a rocking motion

Fig. 958.—Reduction of posterior dislocation. Foot in moderate plantar flexion; thumbs on the front of the tibial shaft; hands clasped about the foot; fingers behind the heel. Reduction is by lift forward in a sweeping motion, while the thumbs exert pressure backward.

applied to the foot, aided by direct pressure. If the displacement is inward, we may wisely rotate as well as rock.

The tendency of the dislocations to recur is dependent on associated fracture. If there is no such fracture, there is no such tendency, so long as the foot is kept at a right angle. Pads beneath the leg above the level of the ankle in anterior dislocations, and a "doughnut" pad beneath the heel in posterior cases, will usually suffice to *maintain* reduction. Lateral luxations do not tend to recur except where there has been severe fracture. Appropriate points for pressure from the inner and outer side to be applied in such cases are shown in Fig. 959.

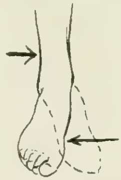


Fig. 959.—Points of pressure to maintain in reduction of *inward* luxation, with or without fracture. Dotted line shows original displacement.

The results of these various luxations, *properly reduced*, seem to be excellent. The tendency to recurrence in case of complicating fracture must be guarded against, of course, and the prognosis in these cases is that of the fracture itself—no worse than in uncomplicated fracture, provided the tendency to recurrence is efficiently dealt with.

Fig. 960.—Compound dislocation of the tibia; avulsion of the malleolus; all the ligaments torn; fracture of the fibula. Drawing made direct from the injured leg. This injury was reduced with a good primary result, but, owing to the extreme crushing of the skin, there was sloughing and late secondary infection, finally necessitating amputation.

FIBULA; LUXATION OF THE LOWER END

This is a very rare accident. The displacement seems to be usually of the fibula backward or outward, with or without some displacement of

the tarsus. The diagnosis depends on inspection and on mobility of the bone. The cause may be either direct or indirect violence.

The reduction is by direct pressure; if there is tarsal displacement also, reduction of this will usually take care of the fibular displacement as well.

Upward luxation (with luxation of the upper end also) has already been considered. It is similarly reduced by reduction of the displaced foot. (See Luxation of Upper End of Fibula, p. 533.)

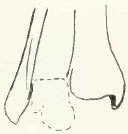


Fig. 961.—Diastasis of tibia and fibula is the term applied where there is enormous tearing and separation, without, or practically without, fracture. This may be so extreme as to permit the ascent of the astragalus between the two leg bones, as is here sketched.

DIASTASIS OF TIBIA AND FIBULA

Fibular luxation *outward* is described as *diastasis of tibia and fibula*, a very rare accident, characterized, of course, by great broadening, and associated with dislocation of the foot (academically, at least) up between the two bones. (See Figs. 960, 961, 962.)

Diastasis of the tibia and fibula may be a complication of various fractures in this region. It is rare at best, and will be considered as affecting only two types of fracture, both to be classed roughly as Pott's fracture. There may be a total separation (diastasis) of tibia and fibula, with a separation of the malleoli and with an ascent of the astragalus between the two bones. A case cited by Cooper is the type, and a sketch from his plate is given in Fig. 962. There should be no difficulty in recognizing this condition, and reduction of the deformity by traction, with maintenance of position by the usual inversion, would seem to promise fair results.

Fig. 962.—A typical Pott's fracture, with diastasis of the bones and dislocation of the astragalus between them (sketched from Cooper's Plate XVIII).

The other type of case is that in which a tearing off of the fibula by rupture of the ligament, or by tearing away of the scale of the tibia to which the ligament is attached, is the equivalent of the fibula fracture, and when accompanied by a fracture of the internal malleolus or a tearing of the internal ligament, gives a clinical picture almost exactly like that of Pott's fracture. Its recognition must be based on the excessive broadening, and especially on the absence of signs of a fractured fibula. Treatment and prognosis are not different from those of the more usual fracture.

Reduction is by traction downward, reduction of the astragalus, by pressure, into its proper relation with the tibia, and then by forcing the two leg bones together by lateral pressure and holding them there.

POTT'S FRACTURE

This fracture, first described by Percival Pott, is accepted as the type of ankle fractures. The name is used to cover many lesions which have nothing to do with what Pott described, and in the large hospitals the house-surgeons and students are very apt to "lump" all the fractures of the ankle together as "Pott's." Pott's fracture is, in fact, a common lesion, but *not* the most common in this region. Fractures involving the fibula alone are certainly much more frequently met with.

What Pott described (in his Chirurgical Works, vol. i, p. 436 of the 1779 edition) is the form consisting of a fracture of the fibula a short distance above the joint, with a dislocation *outward* of the foot and a tearing of the internal lateral ligament. The lesion is shown in an admirable plate in his book. By common consent, however, the term of Pott's fracture is held today to cover also those cases in which a tearing away of the tip of the internal malleolus takes the place of the ligamentous rupture he described. The lesion is in either case the same, so far as treatment and results go. In either case the astragalus is so far loosened in its mortise that it is free to follow the lower fragment of the fibula in its displacement outward.

Fig. 963.—Pott's fracture, with outward dislocation: *a* is not part of the astragalus, but the internal malleolus is torn loose from *b* (courtesy of Dr. C. G. Cumston; *x*-ray by Dr. Percy Brown).

Fig. 964.—Pott's fracture, with extreme tearing of the ligaments. Posterior ligaments all gone; internal malleolus torn loose (drawn from the Warren Museum specimen No. 9581; alcoholic specimen).

The causation of this fracture seems to be, as Stimson has pointed out, not a simple external *rolling* of the foot, as used to be taught, but rather a sharp *abduction* of the foot about a vertical axis, combined with such rotation.* The probable mechanism is that the fibula gives way

* According to Stimson, eversion fractures at the ankle give a break across the fibula low down, while Pott's fracture from twist gives a higher fracture of the fibula, with a spiral line.

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first, and that the continuation of the force tears the internal support of the joint through the ligament or through the bone to which this ligament is attached. The astragalus is *displaced* outward, but is *not* rotated outward unless weight is borne on the foot. There may frequently be an associated backward dislocation, or less commonly a

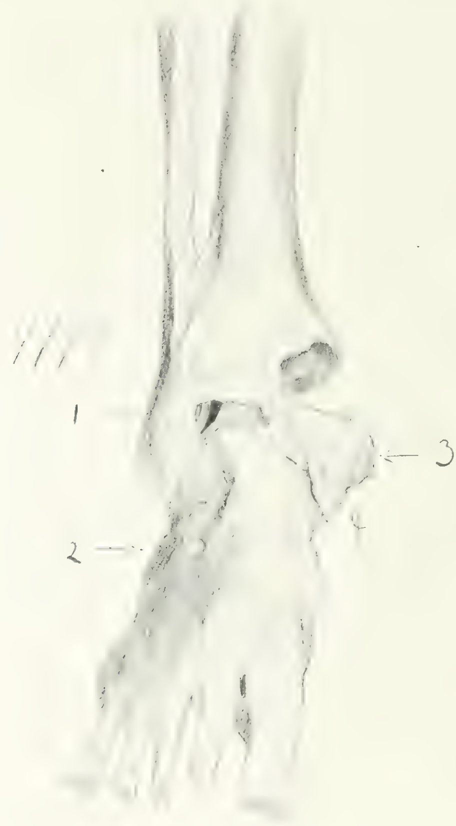

Fig. 965.—Pott's fracture, with extensive ligament tearing: 1, Fibula; 2, os calcis; 3, large fragment of internal malleolus torn off from tibia. Wide tear across the front of the joint, exposing joint surfaces of astragalus and fibula; wide separation between broken malleolus and tibia. (Warren Museum, specimen No. 9774; alcoholic specimen.)

forward dislocation, of the astragalus. These are usually only partial dislocations.

Lesions.—The fracture of the fibula occurs above the joint and above the ligaments—usually two to three inches above the joint. It may be nearly transverse, but more commonly is oblique upward and backward,

with a somewhat spiral fracture-line. The displacement of the fibula is a shoving of the upper end of the lower fragment toward the tibia, while the lower end of the fragment tilts outward. Sometimes the upper end of the lower fibular fragment is tilted sharply forward, the external malleolus displaced backward.

The lesion on the inner side, if the tibia is involved, is merely a tearing off of the malleolus at, or just below, the level of the top of the joint. This fracture is nearly always a clean transverse

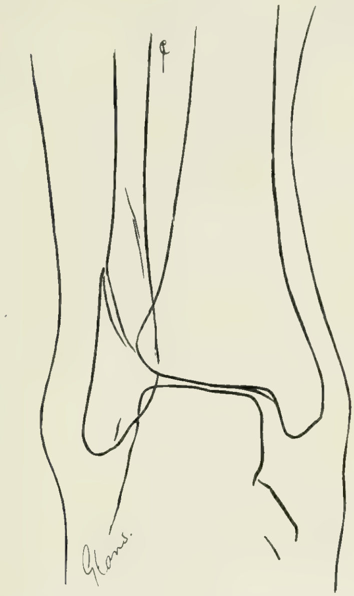

Fig. 966.—Pott's fracture, with increased distance between internal malleolus and astragalus, due to tearing of ligaments.

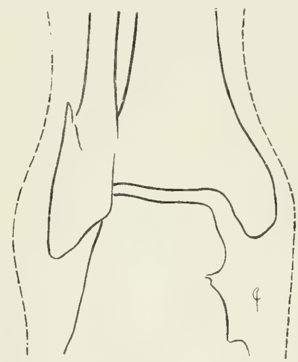

Fig. 967.—Shows the same as Fig. 966.

fracture, unlike that found in the "inversion Pott's." If the malleolus is intact, the internal lateral ligament is torn away close to the tip of the malleolus.

Something more than a simple tearing of this single ligament is

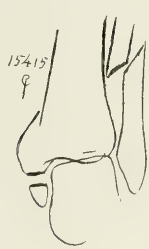

Fig. 968.—Pott's fracture. Displacement of broken internal malleolus not entirely reduced. Astragalus somewhat tilted outward.

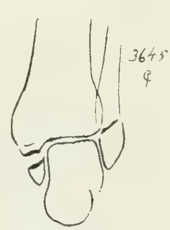

Fig. 969.—Pott's fracture; internal malleolus torn loose; still much displaced. Fracture of fibula unusually low.

probably usual, and must necessarily be present if there is any considerable backward dislocation of the foot. The examination of certain specimens shows that there may also be very extensive tearing across

either the anterior or the posterior capsule of the joint (Figs. 964 and 965).

Pott's fracture is not apt to be accompanied by lesions of vessels or nerves. It is rarely complicated by any injuries to the bones of the foot. Not infrequently, however,

Fig. 970.—Outward displacement in Pott's fracture, not entirely reduced.

Fig. 971.—Pott's fracture, with comminution of fibula. x-Ray outlines reinforced.

Pott's fractures are compound, *always* by protrusion through the skin of the *internal* malleolus or the sharp edge of the tibia, from which the malleolus has been torn away.

Diagnosis of Pott's Fracture.—The symptoms of Pott's fracture are

Fig. 972.—Pott's fracture; foot with astragalus displaced outward and rotated outward. The fibular fragment displaced; the broken internal malleolus dragged downward and inward by its ligamentous connections with the astragalus.

Fig. 973.—Pott's fracture, with unusually large fragment of internal malleolus separated. Old case. Hardly a typical Pott's fracture.

those of an obviously severe lesion. I have known of no case in which the patient could walk after receiving this injury.

The occurrence of great swelling and the formation of blebs are by no means constant, however.

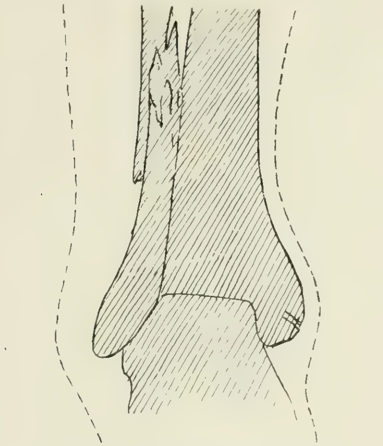

Fig. 974.—Pott's fracture, with splintered fibula, internal malleolus apparently not fully torn off; no displacement.

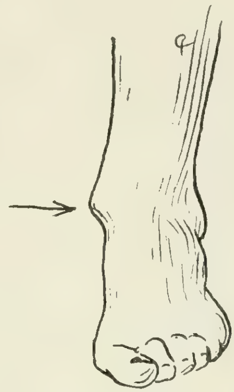

Fig. 975.—Clinically, in Pott's fracture, even where the displacement is not great, we are apt to find a sharp projecting edge at the point here indicated, the edge left where the internal malleolus has been torn away.

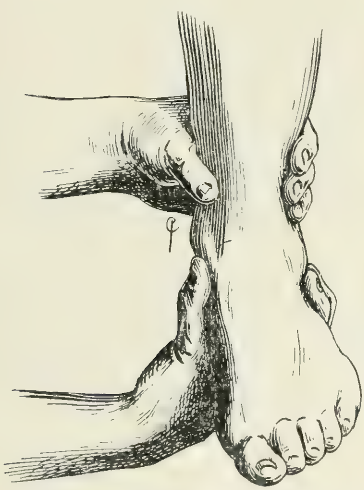

Fig. 976.—Grip to test for abnormal lateral mobility in Pott's fracture.

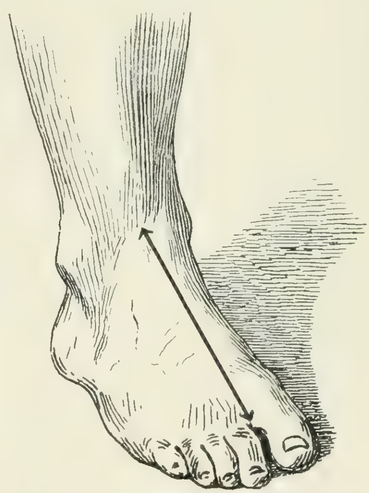

Fig. 977.—Line of measurement to detect backward displacement of the foot on the leg. Measurement from the cleft of the toes to the prominent surface of the front of the tibia.

The pain is not especially great, though the initial shock is apt to be pretty severe for a time.

The foot is held in a position of partial plantar flexion, and in some

cases it is slightly everted. Often enough, however, the deformity has been reduced by bystanders or by the patient before the surgeon sees the case, and the deformity often shows no tendency to recur after such reduction. Eversion of the foot is not a necessary symptom. There is tenderness over the fibula at the point of fracture, and there is marked tenderness at or below the internal malleolus, and at this point there is always some swelling, even within a few minutes after the fracture. (Where only the fibula is broken, we do not get this swelling on the inner side.)

In a Pott's fracture there is no tenderness on pressure *below* the *external* malleolus nor *on* the external malleolus, unless pressure is severe enough to move the fibula. Pressure on the fibula well *above* the site of suspected fracture gives pain *at the level of the break* of the fibula, distinct from any soreness at the point pressed on.

For accurate diagnosis it is necessary to employ the following manœuver.

Fig. 978.—Pott's fracture with considerable outward and apparently some posterior displacement.

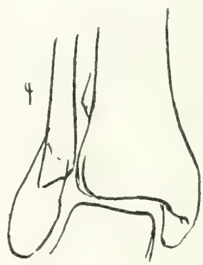

Fig. 979.—Old Pott's fracture, united, with some widening of the joint mortise and some tendency to rotation of the astragalus as a result.

The ankle is grasped with one hand just above the joint, while the other hand is placed beneath the sole, with the thumb on one side of the foot, the fingers on the other below the malleoli (Fig. 976). If the foot is grasped firmly and pushed inward and outward, the presence of an *abnormal lateral mobility* is easily recognized.

Crepitus is also usually felt in the fibula. The presence of a fracture of the internal malleolus as distinct from the ligamentous tear may usually be determined by running the finger down the inner surface of the tibia, while the foot is strongly pushed *outward*. The malleolar

fragment may not always be felt, but the sharp edge of the bone from which it was torn away is always palpable (Fig. 975). For this examination etherization is advisable, but not indispensable.

The test for lateral mobility is the best single proof of Pott's fracture. It occurs in no other fracture except the "inversion Pott's," is readily perceived, and may be $\frac{1}{3}$ or $\frac{1}{2}$ inch in range.

Fig. 980.—Fracture of internal malleolus (fracture of fibula not shown) properly reduced (outlines reinforced).

The question of backward or forward dislocation complicating a fracture may be tested in four ways:

First, by feeling down the front of the ankle for the projection made by the tibia in backward dislocation, by the top of the astragalus if the dislocation is forward. (See Figs. 947, 952 and 956.)

Second, by noting the line of the front of the tibia looked at from the side: this should, under normal circumstances, just about hit the tubercle of the scaphoid if prolonged downward. This rule is not mathematically accurate, but sufficiently so to detect actual displacements (Fig. 943). The tubercle of the scaphoid may always be felt, even through much swelling.

Fig. 981.—Reduction of Pott's fracture with knee flexed, countertraction under the bent knee; foot so grasped as to render downward traction and inversion easy. A preferable method if reduction proves difficult. Not a routine method.

Third, by measurement. (See Fig. 977.)

Fourth, by grasping the ankle as before, grasping the foot as shown in Fig. 957, and then alternately lifting and depressing the foot, we shall reduce—and thereby recognize—any such dislocations as exist. These

displacements are always readily reducible in this way, provided care is taken not to put the tendo Achillis on the stretch during manipulations.

Examination with the x-ray is of service in "checking" the result of a correction and in giving information as to unusual details of fracture-lines. It should not be necessary, however, as a means of diagnosis in these cases.

Treatment of Pott's Fracture.—The first thing is to reduce any displacement that exists. First grasping the foot, as during the examination (see Fig. 976), we force it sharply inward, at the same time somewhat inverting the foot as a whole. Then any possible posterior displacement is guarded against by pulling the heel forward, as in Fig. 958. The foot is then laid in a pillow, still held by the surgeon's hand in the desired position, while the assistant envelops the leg and foot in a pillow and applies straps on the back and side-splints, adding pads if necessary between the splint and pillow, above the ankle on the inner side, and

Fig. 982.—Pillow-and-side-splint. The foot is laid in a large pillow, the middle of which has been pounded down to form a hollow for the foot and leg.

Fig. 983.—The pillow is brought up at the sides and fitted to the leg, and is so folded that it can be comfortably overlapped under the sole of the foot.

Fig. 984.—The edges of the pillow are then pinned in front, overlapped and pinned beneath the sole. Straight side-splints, with or without a straight posterior splint, are then applied and strapped tightly enough to give the necessary support.

opposite the side of the foot on the outer side (Fig. 986). As a rule, the tendency to displacement is only slight, if any, and the position is readily held in this way. The detailed application of this "pillow-and side-splints" apparatus is shown in the Figs. 982, 983, 984.

Only exceptionally is it wise to put on a plaster-of-Paris dressing immediately.

This fracture is a serious one. There may be a good deal of swelling, and not uncommonly there is a formation of blebs, which break, and can best be dealt with *outside* of a rigid plaster-of-Paris dressing.

After three days to a week the plaster-of-Paris dressing may be applied. Any blebs that may still be present may be broken open after alcohol sterilization of the skin, and then dusted over with compound alum or other powder, and a small sterile gauze dressing placed on them.

The limb from the knee to the toes is then wrapped in sheet-wadding, about two thicknesses being used everywhere except at the heel, where

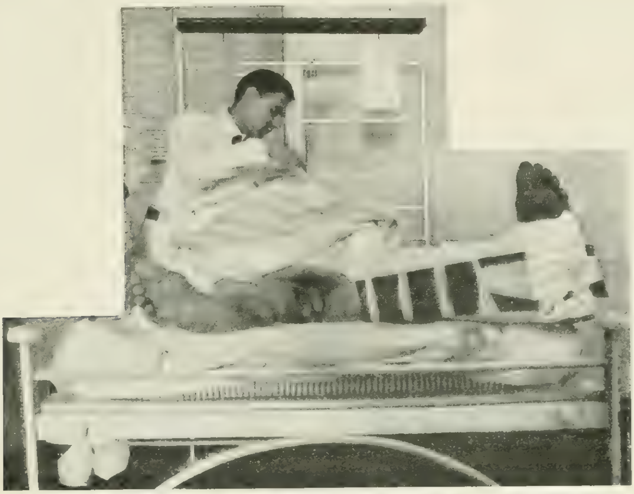

Fig. 985.—Pillow-and-side-splints in actual use. In this case the splints are held in place by bandage instead of webbing straps. An equally serviceable way, but more liable to stretch.

it may be well to make it a little thicker. During the application of this and of the plaster bandage the foot is held by an assistant in such

Fig. 986.—Points at which pressure is to be made in retaining Pott's fracture in place, whether in splints or plaster. Pressure on the inner side is to be made on the tibia above the joint; on the outer side pressure is to be made on the foot, both on the outer side of the os calcis, and over the cuboid and fifth metatarsal.

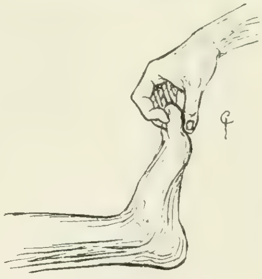

Fig. 987.—Holding the foot by the toes during the application of the plaster bandage. The most serviceable method in most cases when there is no tendency to anterior displacement. Curiously enough, this is not only effective, but is comfortable to the patient.

fashion as to prevent displacement. If there is no anterior dislocation, the best way to hold it is by the toes, as shown in Fig. 987.

The plaster is laid on in circular turns from below the knee* to the

* Only in case of tendency to rotatory displacement need the plaster go above the knee.

toes, carefully avoiding any tension during the application of these turns. When the bandages are all on, the surgeon grasps the foot, with one hand pulling outward, pressing just above the internal malleolus: with the other hand the heel and foot are so grasped that the fingers hold the heel, while the base of the thumb exerts a pressure inward on the outer side of the foot (Fig. 988). Care must be taken that this pressure is exerted evenly over a considerable surface. With the hands in this position the foot is held inverted and is sharply shoved inward. A moderate inversion is enough. Pressure inward is limited only by what we think the outer side of the foot will stand without slough and without much pain. There is no danger of shoving the foot too far. The external ligaments permit no motion beyond the normal position of the astragalus. The pressure of the surgeon's hand is kept up until the plaster is reasonably firm.

Fig. 988.—Grasp of hand on plaster-of-Paris bandage (begun while the plaster is still soft and maintained until it is thoroughly set), to insure reduction and the maintenance of pressure at the points noted in Fig. 986.

Care must be taken to secure, as nearly as may be, a right angle between the leg and foot. Failure to do this means difficulty in walking during early convalescence and possible impairment of ankle motion permanently.

The plaster should be trimmed so that no uncomfortable pressure is exerted on the little toe or on the distal end of the fifth metatarsal, and should be cut behind the knee to such an extent that moderate flexion of the knee will not cause it to dig into the skin.

The foot may be laid in any position that is comfortable. Usually patients prefer to have the toes pointing upward or to have the foot somewhat turned on its outer side, with the knee slightly bent and supported by a pillow or sand-bag.

For this reduction of the fracture, which is meant to be permanent, it is usually well to give ether if practicable, though it is often not necessary. In very nervous or very muscular patients it is hardly possible to do good work without ether, and in most cases it is of advantage to use it if we can.

After-treatment of Pott's Fracture.—Not infrequently there is some pain following the application of plaster, pain resulting from tension. This lasts but a couple of days at worst, and may be combated with morphin, but must be differentiated sharply from pain due to pressure, which means trouble and calls for cutting of the plaster. Pain from

pressure is persistently localized at the point of pressure, and usually, unlike tension-pain, tends to increase and not decrease from the beginning.

The first thing to be done in the way of treatment after the plaster is on is to get an x-ray if possible. Good enough x-rays can be obtained through a plaster dressing after it is fully *dry*—that is, after two days at most—to tell us all we need to know about reduction in these cases. At any time within two weeks we can correct misplacements that may have escaped notice, and can correct them usually without ether. After this date, information of this sort is apt to be useless.

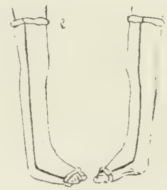

Fig. 989. — Proper lines for cutting plaster. Plaster so cut may be strapped together with adhesive plaster or with webbing straps so firmly as to have much of its original efficiency.

If everything is going well, *and if there was no great swelling when the plaster went on*, there is no reason for cutting down a good plaster earlier than three weeks from the time of injury. By this time union is beginning; there is no tendency toward displacement, and we may wisely begin massage and guarded motion. Active motion is less likely to do harm than passive, and is preferred. The plaster may be removed once or twice a day for this purpose, and then strapped on again.

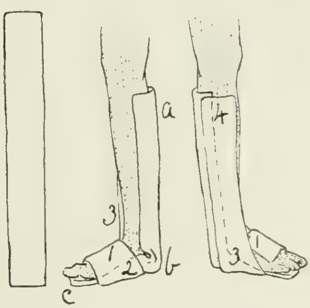

Fig. 990. — Stimson's dressing for Pott's fracture or fracture of the fibula. Two long strips of plaster, 6 inches wide, about 10 inches longer than the distance from the heel to the popliteal space, and about 12 bandages thick, are prepared. One of these is laid on the leg, over light padding, on the back of the calf, under the heel, and up over the sole of the foot. (See sketch, *a*, *b*, *c*.) The other starts on the dorsum, goes outward under the sole, and up the outer side of the leg (see in sketch 1, 2, 3, 4). These are rubbed together where they overlap, and bandaged in place.

If backward or forward dislocation is present with the fracture, as shown by the x-ray, it is obvious that attention should be paid particularly to a proper support of the heel until union is firm, and that weight-bearing should be begun very carefully.

By the end of the second week the patient should already be on crutches in most cases. In cases without great tendency to swelling there is no reason why crutches should not be used more or less cautiously after the first week.

No weight is to be borne on the foot until after at least a month, and no considerable weight for about six weeks. At this time it is wise, especially in heavy patients, to fit a metal foot-plate as for flat-foot. The tendency to a weakened arch is almost universal after this form of fracture; with due care during convalescence the necessity for a plate is only temporary. Sometimes it may be well to use strapping (see Fig. 991), as well as a plate. Strapping is often useful before the plate can be fitted.

The only alternative to the plaster dressing of the ordinary type is the ingenious modified plaster introduced by Dr. Stimson* (Fig. 990). This I have repeatedly used, and found it very satisfactory, although it is not quite so rigid as the ordinary form, and is better suited for the more careful class of patients. It is made of the ordinary plaster bandage, wet, laid over and over on a board in such fashion as to make a bandage of 10 to 15 thicknesses, and about 6 inches wide, long enough to reach from the knee around the heel up the sole of the foot to the tip of the toes. A second similar strip is prepared of the same thickness and a little longer. The foot and leg are wrapped in sheet-wadding in the usual way. These plaster strips, still soft, are laid on as shown in Fig. 990, the edges of the two being rubbed together where they overlap, and the whole is held in place by a gauze bandage wrapped around outside. The correction of the fracture and the securing of inversion are then carried out with the hands as described above; after the plaster has set the gauze bandage is removed, the corners of the plaster are trimmed to suit, the sheet-wadding is split and trimmed away over the front of the leg, and the dressing is finished by a few turns of ordinary bandage carried around the upper end about the leg.

Fig. 991.—Pad and adhesive-plaster strap to maintain the arch of the foot after fracture

It is distinctly more comfortable than the ordinary plaster, and better permits the inspection of the leg and ankle.

End-results.—A consideration of the end-results of this fracture will be postponed to the end of this chapter, when end-results of this and of other ankle fractures will be considered.

POTT'S FRACTURE WITH SPLITTING OFF OF THE POSTERIOR SURFACE OF THE TIBIA

This is a not very uncommon lesion, and a very serious one, meaning, as it does, not only a dislocation backward, but a dislocation with a great tendency to recur.

The lesion is a splitting-off of the posterior internal edge of the tibia, including usually a third to a half of its depth. This fragment may be in one piece with the portion of the malleolus that is knocked off.

The lesion is here classified as a variant of Pott's fracture, although it should probably be made a separate type. There are no anatomic

* The old-fashioned carved side-splints are *not* an efficient dressing.

specimens of the fracture that I know of, but, judging from x-rays and cases operated, I should describe it as a lesion consisting of a *tibial fracture,* in which the fracture-line separates the internal malleolus and

Fig. 992.—x-Ray of a posterior dislocation, with fracture and displacement of the posterior edge of the tibia.

runs backward (probably in a curved plane) in such a way as to split off the whole back edge of the tibial articulating surface, and of a *fibular* fracture a little *above* the ankle-joint.

The attachments of the posterior capsule are not torn, and the astragalus drops back, accompanied by the internal malleolus with the posterior fragment to which

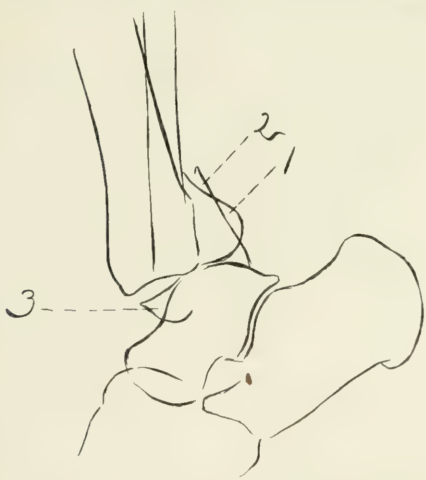

Fig. 993.—Posterior dislocation, with fracture of the tibia and fibula at the ankle: (1) Posterior fragment of tibia; (2) fragment of fibula; (3) internal malleolus broken off.

Fig. 994.—Front view of case shown in Fig. 993. The posterior fragment of the tibia did not show in this view.

the capsule is attached, and is drawn up behind the tibia. With this displacement we often have the familiar deformity of Pott's fracture—displacement outward.

Diagnosis. Diagnosis depends, first, on recognition of the backward dislocation, and on observation of the tendency to recurrence.

Fig. 995.—Fracture of the posterior edge of the tibia, with luxation backward of the foot. Diagnosis doubtful in detail. (Warren Museum, specimen No. 5915^{40}. Plaster cast.)

Fig. 996.—If there is a dislocation *with* fracture, the total backward displacement is less; the palpable projection of the tibia forward is less, and the lesion is more readily overlooked.

The trouble is that it is difficult to say whether or not a posterior dislocation is or is not accompanied by such a fracture, for dislocation may, perhaps, recur. Crepitus does not help us; it is present anyhow. The one point that can help is that the prominence of the front edge of the tibia is less than would be the case in dislocation (Fig. 996).

Fig. 997.—Fracture of the posterior edge of tibia, with fibula fracture, with backward luxation. Old case, consolidated with nearly useless ankle: 1, Fragment of tibia; 2, fibula (lines reinforced).

Fig. 998.—Fracture of posterior edge of tibia, with slight displacement backward.

I have recognized and successfully reduced this fracture in three cases before the skiagraph was taken; ordinarily, confirmation by the *x*-ray will be sought rather before than after, if this lesion is suspected.

There is reason for thinking such fracture very common in proportion

to the number of backward dislocations with fracture, and probably it may be well, in case of backward dislocation-fracture, to *assume* that

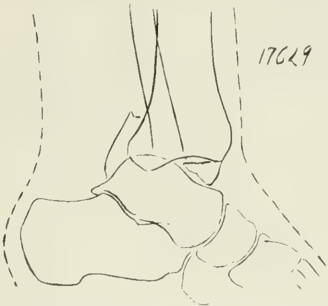

Fig. 999.—Pott's fracture, with lateral and posterior displacement, *without* evident fracture of the back edge of the tibia.

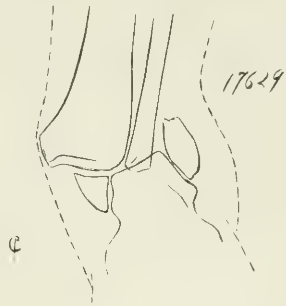

Fig. 1000.—Same case as Fig. 999.

Fig. 1001.—Posterior dislocation of the ankle, with Pott's fracture and a splitting-off of the posterior edge of tibia. Foot slipped off the mat during wrestling bout. Extreme displacement, promptly reproducing itself after reduction. This plate was taken one week after permanent reduction, and showed only an oblique line of fracture of the back edge of the tibia, practically without displacement. This plate shows in reproduction only the break in the cortical layer of the back surface of the tibia. This was a perfect reduction, with perfect and rapid recovery of function and motion (x-ray plate by Dr. Percy E. Brown).

fracture of this posterior lip is present, and not to trust too much to the probability of a reduced dislocation staying in place.

As to frequency, I can only say that I have treated 4 fresh cases of this injury, have seen *x*-rays of 5 more, and have operated on 3 old cases in which this was the obvious original lesion, within about four years.

If this lesion is promptly recognized, there is no difficulty in reducing the fragment and no great difficulty in holding it. I have found it necessary to use plaster-of-Paris from the first, and have employed a position of maximum dorsal flexion to prevent redisplacement.

After-treatment.—After-treatment is that of Pott's fracture, with the difference that the absence of a firm tibial surface to bear weight will incline us not to allow *weight-bearing*, in most cases, under eight weeks.

Results.—The results in properly reduced cases have been perfect. Where the deformity has been allowed to persist, there has been grave disability, due to the imperfect mechanism of the altered joint, resulting in loss of motion and lameness. These cases have been greatly benefited by operation, but not restored to normal.

INVERTED POTT'S FRACTURE

This lesion, somewhat similar to Pott's fracture, is produced by a simple inversion of the foot. Both fibula and internal malleolus are

Fig. 1002.—Typical inversion Pott's fracture. Fibula broken at the level of the joint. Internal malleolus broken off obliquely and displaced inward (outlines reinforced).

Fig. 1003.—A typical case of inversion Pott's fracture. Extra large inner fragment.

broken, but in a different line from that found in the ordinary form. Of the exact mechanism of the fracture nothing is known except that forced inversion causes it: probably inward rotation plays a part. It seems probable that the tibia gives way first.

The lesion is often confused with Pott's fracture, sometimes with deplorable results, for the treatment is very different.

Lesions.—The fracture of the fibula in these cases occurs at about the level of the joint, or a little above it; invariably lower than the height usual in Pott's fracture. The fracture of the internal malleolus is not a breaking off of the tip, but a breaking away of the whole malleolus, usually in a line somewhat oblique, upward and inward. This line starts not lower than the angle in the articular cartilage between the internal malleolus and the bearing surface of

Fig. 1004.—Inverted Pott's fracture. Fibrous union of tibia; bad position.

Fig. 1005.—x-Ray of same case as in Fig. 1004 (outlines reinforced).

Fig. 1006.—Typical inversion Pott's fracture. Evidently only one edge of the fracture plane is shown. Poor plate (outlines reinforced).

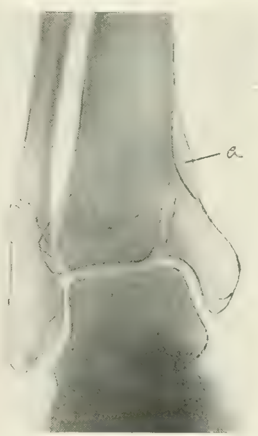

Fig. 1007.—Inversion Pott's fracture (outlines reinforced).

the tibia, and may encroach considerably on this bearing surface. The liability to tearing of ligaments and to backward and forward disloca-

tion seems less in these cases than in Pott's fracture, and they are less apt to be compound.

Diagnosis.—Here, as in Pott's fractures, there may be no deformity at all at the time the case is seen. There may be, however, especially

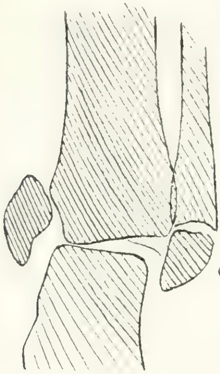

Fig. 1008.—Typical inversion Pott's fracture. This case united only by fibrous union, was opened down on, refreshed, and pegged temporarily. Perfect result (x-ray 15975).

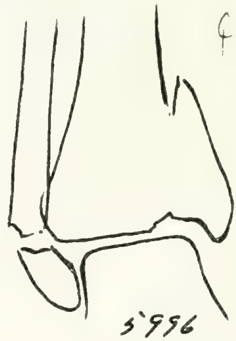

Fig. 1009. — Inversion Pott's fracture. Sketch from x-ray plate.

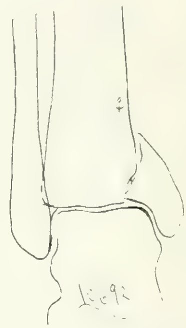

Fig. 1010.—Fracture of the internal malleolus, apparently by inversion; no fracture of the fibula.

in the cases that run well into the tibial articular surface, a marked inversion and inward displacement of the foot, hard to correct, and recurring very easily.

Fig. 1011.—Application of pressure and pull to reduce and maintain reduction of inversion Pott's fracture.

Fig. 1012.—Lane staple (Terry's modification), used in place of a nail. This staple is left in the tissues. x-Ray, outlines reinforced, of case of "inversion Pott's."

Lateral mobility is obtainable by the same test as with Pott's fracture, but the free mobility is *inward*, not outward.

Tenderness on the inner side is found higher up in this form, and there is usually no difficulty in palpating the fragment of the tibia or in obtain-

ing crepitus. On the outer side tenderness is not above, but just about *at*, the joint, and the swelling involves the outer side of the foot.

Treatment.—If there is no great tendency to displacement, the foot is to be put up at first in pillow and side-splints. In cases in which there is inversion it may often be necessary to put on a plaster immediately because the deformity cannot be prevented from recurring in any other way. In this case the plaster must be padded with unusual care, and will have to be changed as soon as the swelling goes down.

The position to be aimed at is in this case not an overcorrection, but a correction to normal. Overcorrection, even if attainable, would carry too much chance of a later flat-foot.

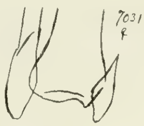

Fig. 1013.—Inversion Pott's fracture. Fibula fracture unusually high.

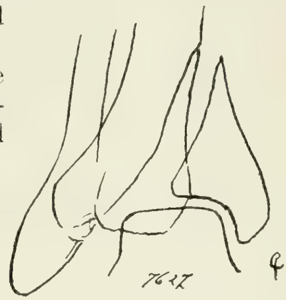

Fig 1014.—Inversion Pott's fracture. Unusually large inner fragment (sketch from x-ray).

After-treatment.—This is carried out on the same lines as with the ordinary Pott's fracture, excepting that in cases where there has been much tendency to inversion (meaning usually a splitting of the fragment well into the joint on the inner side), weight-bearing may well be postponed a little longer in this form.

Long-delayed union or even non-union sometimes occurs in this form, *as it apparently does not in true Pott's fracture.**

FRACTURE INVOLVING BOTH BONES JUST ABOVE THE JOINT

Fractures just above the ankle are not to be distinguished, so far as the cause is concerned, from those through the joint level, save for the few that result from direct violence. As might be expected, they show no constancy in the obliquity of the line. In a general way the same line is continued through both bones. Inasmuch as there is no long bone left to maintain the length of the leg, the displacement in fractures of this type may be extreme, and it is very common, relatively speaking, to have projection of one fragment of the tibia through the skin. There is no difficulty about the diagnosis of this type of fracture, unless in regard to the exact line followed. Like fractures higher up in the leg, these may not uncommonly be spiral rather than directly oblique, and, like other spiral fractures, may show a chipping off of one or the other tip of bone fragment. There may be much comminution of bone. Inasmuch as the strong muscles of the leg have free

* Within three or four years the writer has met with two cases of non-union—one united after operation (Fig. 1008); in the other (Fig. 1004) union was never better than fibrous. Stimson and others have recognized the same tendency.

Fig. 1015.—Fracture of the tibia low down; marked outward bowing; union. (Warren Museum specimen 1146.)

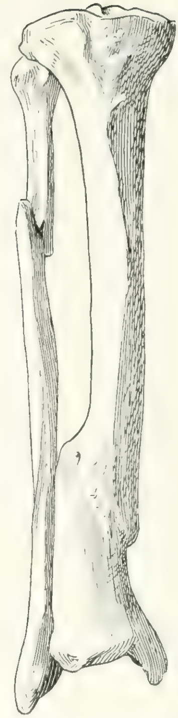

Fig. 1016.—Fracture of the tibia, low, oblique; considerable displacement. High fracture of fibula (drawn from Warren Museum specimen No. 8303).

Fig. 1017.—Fracture of both bones low, slight displacement (courtesy of Dr. McKechnie, of Cambridge). The patient walked on this leg to some extent for ten days before seeking a doctor.

Fig. 1018.—Side view of same case as Fig. 1017. It is interesting to note that the apparent separation of the internal malleolus at the point shown by the arrow is an illusion; there is no break at this point (x-ray by Dr. McKechnie).

action in these cases there may be extreme deformity in any direction, according to the muscle pull, as well as gravity. As these fractures most commonly come from an outward twist of the foot, the deformity to be combated is apt to be in this direction. Backward or forward bowing is not unusual. In children these fractures may be of "greenstick" type.

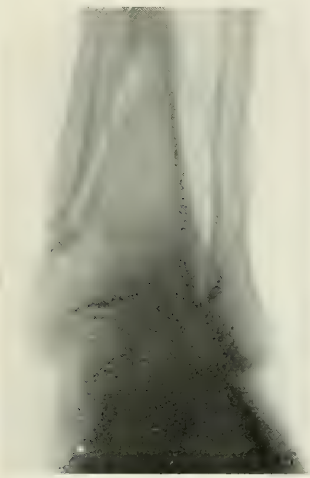

Fig. 1019.—Oblique spiral fracture of tibia close above joint. Fracture of fibula at higher level.

Fig. 1020.—Side view of same case as Fig. 1019.

Fig. 1021.—Atypical fracture from a fall on the foot. Fracture of the internal malleolus; fracture of the fibula; separate transverse fracture of the tibia above the joint.

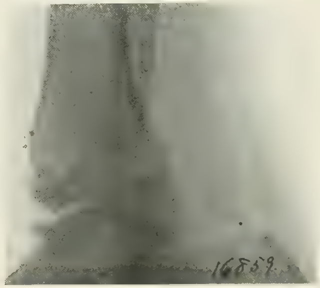

Fig. 1022.—Side view of same case as Fig. 1021. This case recovered with practically no deformity, perfect motion, perfect function.

Diagnosis.—Mobility of both malleoli (with the foot) on the leg settles the diagnosis. Only in case of great swelling should there be any trouble in diagnosis.

Treatment.—If such fractures are compound, they will often need some artificial fixation applied through the open wound. By choice

Fig. 1023.—Irregular oblique splintering of the lower end of the tibia; fibula fracture higher up.

Fig. 1024.—Spiral of the tibia, low.

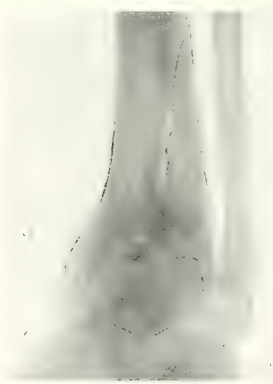

Fig. 1025.—Long split into joint; low fracture of fibula: (1) Internal malleolus; (2) front edge of tibial fragment; (3) top of astragalus (outlines reinforced).

Fig. 1026.—Fracture of the tibia close to the joint, with some backward displacement (x-ray 15945). This seems to be a fracture by avulsion from plantar flexion, but this is not certain.

this will be a suture of kangaroo tendon through the bone edges, or a

steel staple.* At times it is possible with the compound spiral fractures, to obtain *exact* reposition, in which case the tendency to displacement practically disappears. This means exact reposition of the

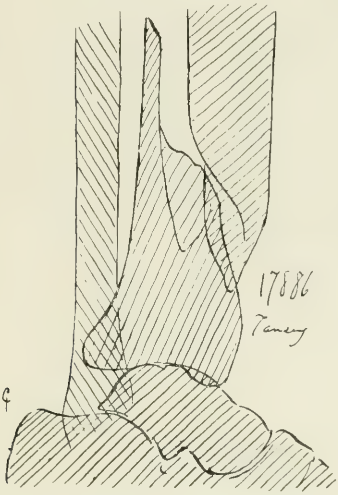

Fig. 1027.—Sketch of x-ray of a fresh case, similar to that shown in Fig. 1024.

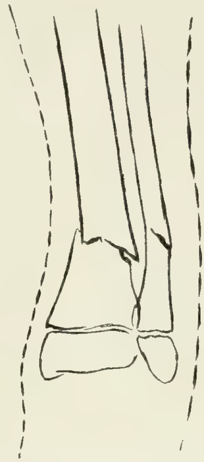

Fig. 1028.—Fracture of both bones, low; that of the fibula a greenstick fracture only.

tibia: exact reposition of the fibula is hardly possible, and is of no importance.

If the fracture is simple, there is usually a good deal of swelling, and

Fig. 1029.—Fracture of both bones, low down; displacement slight (x-ray No. 9136).

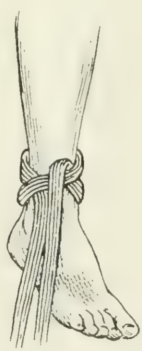

Fig. 1030.—Clove-hitch for getting a traction grip on the ankle, for reduction.

pillow and side-splints for a few days may be sufficient, as they are

*Of the type originated by W. Arbuthnot Lane; this staple represents a greater advance than his more recent bone-plates, in my opinion. (See Fig. 1012.)

Fig. 1031.—Comminuted fracture of tibia, low.

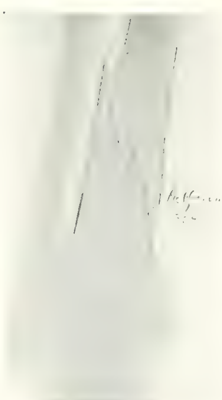

Fig. 1032.—Oblique fracture of tibia, low.

Fig. 1033.—Greenstick fracture of both bones.

certainly desirable. As a rule, however, the tendency to displacement is so great that an immediate plaster-of-Paris dressing is necessary to secure decent position.

In these fractures above, but close to, the joint, it is often justifiable,

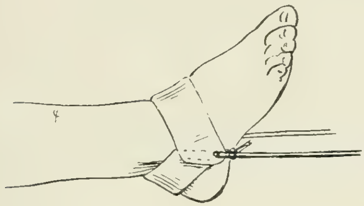

Fig. 1034.—Leather or cloth anklet for getting traction on the ankle.

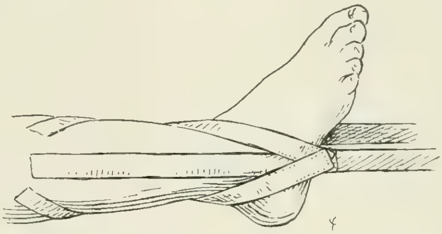

Fig. 1035.—Adhesive-plaster strapping to the foot and lower leg; may be used with weight traction to get a pull on fractures even close to the ankle.

in the interest of accurate replacement, to allow some plantar flexion of the foot. To insist upon the right angle is often to insure backward bowing at the point of fracture.

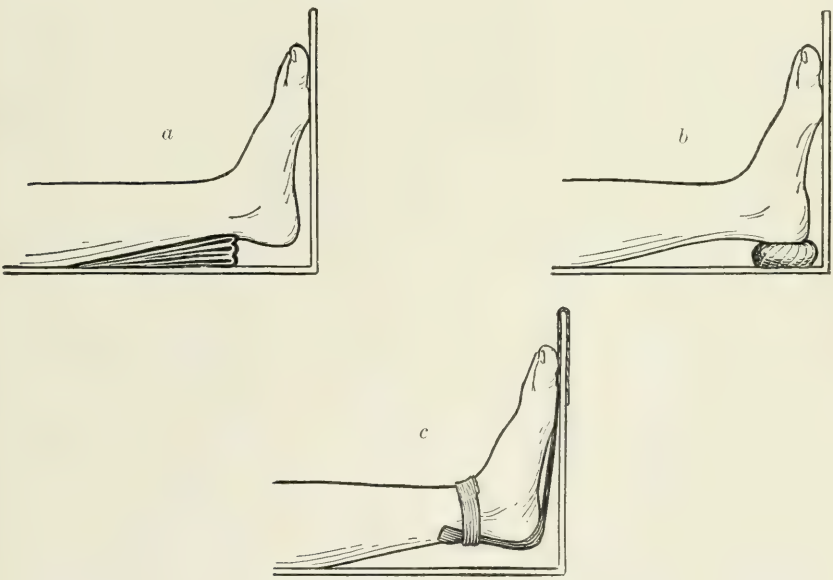

Fig. 1036.—Methods of supporting the foot when using a posterior splint. *a*, Padding beneath tendo Achillis; *b*, ring under heel; *c*, sling of adhesive plaster.

Plaster is usually sufficient to maintain tolerable position. Now and then active traction is necessary. This may be obtained most readily with an anklet or by applying adhesive plaster to the foot and heel, and

exerting pulley traction on this, while the leg is properly supported and steadied in plaster with proper pads. A weight of five to twelve pounds will usually suffice. Such traction may be removed at ten days to three weeks without recurrence of the shortening, and an ordinary plaster bandage may then be applied.*

A "posterior wire" splint with flat side splints may be made to do excellent service in this class of cases, but a certain familiarity with its use is essential to the best results. It is not to be recommended for general use. (See Figs. 916, 1036.)

Whatever the line of fracture in these cases, it must be remembered that an inward deviation of the foot is of far less importance than an outward displacement, and that a backward bowing usually means definite disability. In the severer fractures at this point some deformity is inevitable, and it is within our power to choose in which direction this slight deviation shall be.

SEPARATION OF THE LOWER EPIPHYSIS OF TIBIA AND FIBULA

Epiphyseal lesions at the ankle are rather uncommon.† At times some peculiar cross-strain in a child gives rise to *separation of epiphyses*

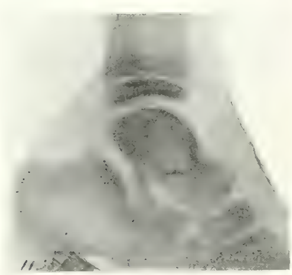

Fig. 1037.—Normal epiphyses at ankle (*x*-ray).

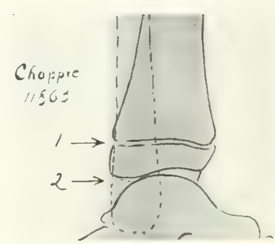

Fig. 1038.—Actual case of separation of lower epiphyses of tibia (*x*-ray after reduction): 1, Level of tibial epiphysis; 2, level of epiphysis of fibula.

of both tibia and fibula. Such separations may occur up to sixteen or seventeen years of age. Save for the *soft* crepitus, they are hardly to be recognized from transverse fractures. The nearness of the lesion to the joint and the directly transverse direction of the displacement are, of course, suggestive. The displacement in these cases seems apt not to be very great. Not rarely the fibula is broken just above the epiphysis, with the tibia gone at the epiphyseal line.

* Up to recent years the "short Dupuytren splint" was much used for traction, but is now practically abandoned. It is efficient, but not comfortable or handy.

† A good many cases are on record. Monod (Revue d'Orthopedie, 1901, No. 2) reports a recent case that is typical. Most of us have seen one or two.

As with most other epiphyseal separations, replacement is not difficult. In this case the separation follows the epiphyseal line closely, as a rule.

The tibial epiphysis is cap-shaped, and does not tend to become displaced when once *exactly* reduced.

Separation of the epiphysis of the fibula *alone* is rare.* It is mechanically the equivalent of fibula fracture. The diagnosis rests on the patient's age, the location of the lesion, and the presence of cartilaginous crepitus, if any. I have read of no case in which there was any considerable displacement or any difficulty in reduction or retention.

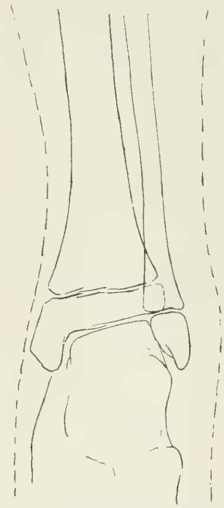

Fig. 1039.—Normal epiphyses at the ankle (x-ray sketch).

FRACTURE OF THE FIBULA ALONE, AT OR ABOVE THE JOINT

Fracture of the fibula alone may result from a force which, if sufficient, would have produced a Pott's fracture, or more often from a simple inversion of the foot, such as more usually causes a simple sprain.

It is the commonest type of ankle fracture.

Lesions.—The fibula may be broken across at any level, more usually within a few inches of the joint. If the fracture is well above the joint, it is very apt, unless the result of a direct blow, to partake more or less of the spiral type.

Fig. 1040.—Fracture of the fibula alone (sketch from x-ray 8739).

Fig. 1041.—Fracture of fibula alone (sketch from x-ray 8679).

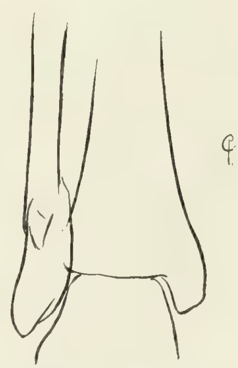

Fig. 1042.—Fracture of fibula alone (sketch from x-ray 8825 *a*).

* Even Poland's great work records but four instances of this lesion.

Fractures may occur within the area of insertion of the tibiofibular ligament. Such fractures show slight displacement, and are apparently usually the result of inversion, while the fractures higher up may occur from any form of twist or from a blow. The fractures very close to the joint level may show any line of break, but are more apt to be transverse, or nearly so, than in the case of fractures higher up.

Diagnosis.—Fracture of the fibula does not destroy the mechanical strength of the ankle-joint to any great extent. Commonly enough, such a fracture is not more painful than the average sprain. Patients can perfectly well walk after this injury, though not without pain. The classic instance is that of John Wilkes Booth, who, after the assassination of Lincoln, escaped, despite the fact that his fibula had been fractured in the leap from the stage. Similar instances are by no means uncommon.

Fig. 1043.—Fracture of fibula alone.

Fig. 1044.—Lateral view of fracture of fibula. Reproduced here to show how vague the lateral view is as to diagnosis. The fracture of the fibula may be shown or may not, but we are left entirely in the dark as to any damage to the tibia (lines reinforced).

If the fibula has been broken, there will be local tenderness at the point of the break. This tenderness will, of course, extend all about the circumference of the bone. If the break is above the ligaments, pressure on the fibula above the break will give pain at the site of injury. If the break is through the ligamentous attachment, this sign is not trustworthy. With fracture by eversion there may be slight tenderness on the inner side of the ankle; there is no tenderness on the outer side, except directly about the fracture. Inversion strain gives tenderness

below the external malleolus, and up along the peroneal tendons, irrespective of the condition of the fibula.

If the fibula has been fractured well above the joint, referred pain on pressure above the fracture and tenderness of the fibula *itself* will give the diagnosis. If the fracture is lower, there will be local tenderness at some portion of the *subcutaneous* area of the fibula. (See Fig. 1046.) This subcutaneous area cannot be involved and is never tender in cases of simple sprain, therefore tenderness here is apt to be significant.

Ecchymosis and swelling may be very slight or absent, and pain (distinguished from tenderness) may be trifling.

Laxity of the mortise with abnormal lateral mobility is the exception in fractures of the fibula alone.

Tenderness about the ligaments between tibia and fibula, well localized at the front, is common to most sprains, as well as breaks, and is practically without value in distinguishing between the two. It may mean tear—it certainly does not mean fracture.*

Treatment.—These cases require simply rest until such time as the fibula has begun to be firmly held by callus. Malposition is apparently of no consequence whatever, and trifling malposition certainly calls for no painstaking reduction. Such reduction is, moreover, impossible to secure with any accuracy because of the intact tibia. We have no leverage that can be used.

If such cases are allowed to walk early, they become disabled presently on account of the development of tenderness about the site of fracture, and callus-formation may then become excessive.

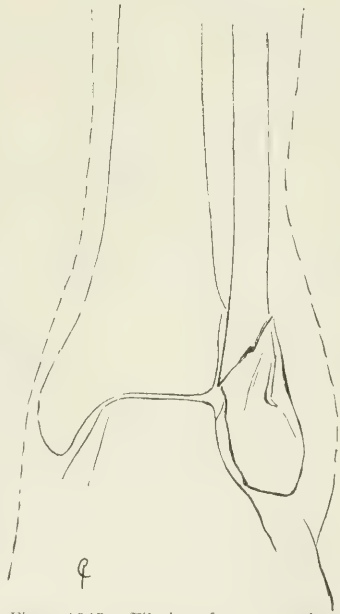

Fig. 1045.—Fibula fracture alone (sketch from x-ray).

If they are allowed to remain in plaster for two or three weeks, there is no objection to allowing moderate weight-bearing after this date, with *progressively* increasing use of the foot. After removal of the plaster-of-Paris adhesive-plaster strapping of the Cottrell-Gibney type is often of service. (See Fig. 1047.) If there is any tendency to flat-foot, temporary padding (of saddler's felt sewed in a leather insole) may be of service, and is often advisable, or a metal plate may be needed. (See Fig. 1048.)

* In one case observed tenderness at this point in a *sprain* was followed by periosteal thickening—evidently the ligament insertion had been lifted from the bone.

Massage and passive motion are usually superfluous in this lesion, except for comfort.

Fig. 1046.—Shaded area shows the *subcutaneous* surface of the fibula.

Fig. 1047.—Cottrell-Gibney adhesive strapping for convalescence in ankle injuries.

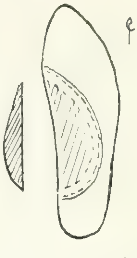

Fig. 1048.—Padding of felt sewed to leather insole. The area of the pad (sloped to nothing at the outer edge) is shown at the right. The thickness of the pad in elevation is shown to the left.

Fig. 1049.—Fracture of the left fibula near the lower end; united. View from outer side. (Warren Museum, specimen 1150.)

Fig. 1050.—Fracture of the tip of the lower end of the left fibula; united. View from inner side. (Warren Museum, specimen 1151.)

FRACTURE OF THE EXTERNAL MALLEOLUS

Fractures of the external malleolus are not uncommon, occurring usually a little below the level of the ankle-joint proper. They are apt to be nearly transverse. As a rule, they seem to result from inversion of the foot.

Diagnosis.—The disability is about the same as in the low fractures of the fibular shaft. Pressure on the fibula higher up is *not* painful. Swelling is about the same as in an ordinary sprain. The diagnostic feature is that the pressure upon the external malleolus (at a point where it is subcutaneous) is painful. Pressure at this point in a sprained ankle is *not* painful. Crepitus may occasionally be made out, and if swelling has not yet become considerable, it may be possible to make out mobility of the lower fragment by grasping it in the fingers. Mobility

of the ankle, due to loosening of the mortise, is so slight as not to be a serviceable point in diagnosis.

Treatment.—As with most other fibula fractures, no reduction is necessary; simply rest and fixation in a natural position are called for, with the foot at or near the right angle.

This fracture should fall within the rule of fractures largely included within the joint cavity, but does not, in fact, show any tendency to non-union, so far as I know.

A fixation of three weeks, with gradual resumption of function, is sufficient for excellent results.

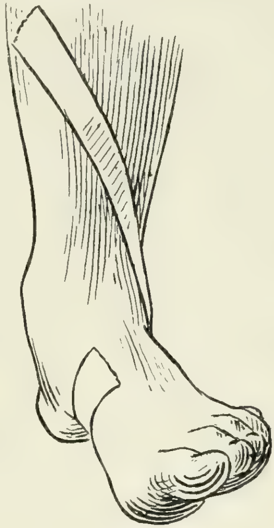

Fig. 1051.—Adhesive-plaster strap to prevent inversion of the foot in fractures of the external malleolus.

COMPOUND FRACTURES AT OR NEAR THE ANKLE

These are uncommon. Least unusual is the type in which the sharp edge left at the end of the tibia, by separation of the internal malleolus in Pott's fracture, is driven through the skin as the foot is carried outward.

Nothing need be said save as to the gravity of compound fractures here as a class, a gravity due to the fact that the joint is opened and is in communication with the outside wound, and that the foot is not a very clean region.

Aseptically handled, these cases give results about as good as in the simple cases, though results are obtained, as a rule, somewhat more slowly.

Fig. 1052.—Sketch from the x-ray of a case of fracture of the external malleolus into the joint without displacement. (Sketch from x-ray 980.)

If sepsis occurs, the results *must* be poor. Often they are very bad indeed, for the difficulty in holding the fragments is great, and when union at length occurs, the position is usually bad, to say nothing of the stiffness.

COMPLICATIONS OF ANKLE FRACTURES

The complications on the part of nerves and vessels in these cases of ankle fracture are surprisingly few; they seem limited almost entirely to such nerve injuries as cause occasional paresthesia in the fore part of the foot, and such injuries of the veins as apparently give somewhat more swelling than would be looked for *below* the point of hurt. It is somewhat surprising that the injury of the fibula at the lower end may

not only show marked displacement, but even a marked displacement backward into the region of the nerve, apparently without impinging on the nerve at all.

Fig. 1053.—Situation of swelling and ecchymosis in the usual ankle sprain; this ecchymosis is in the looser tissues, not in the tendon-sheaths or deeper structures.

Fig. 1054.—The cross-shaded areas show the points where joint effusion and tenderness are most obvious in synovitis. The dotted ellipse shows the area involved in swelling after sprains, etc., usually called tenosynovitis.

As a matter of fact, forward or backward displacement of fragments of the fibula seems to be of little or no importance at any point below the middle of the bone.

SPRAINS OF THE ANKLE

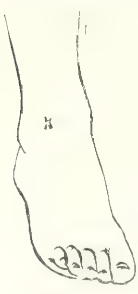

Fig. 1055.—The point X shows a common point of maximum tenderness in ankle sprain. This is over the anterior tibio-fibular ligament; at times there is later a thickening at this point; evidently this is when ligament fibers have been pulled loose from the bone.

These injuries are very common indeed. They result, as a rule, from "turning the ankle"—*i. e.*, from a misstep in which the foot is twisted *inward*. There is a sharp, sickening pain and some immediate loss of use. In the common inversion sprains the damage, as shown by early subjective as well as objective signs, is entirely on the *outer* side of the ankle.

There is enough strain or tear of tibio- or fibulo-astragaloid ligaments to determine, as a rule, some synovitis of the ankle, with soreness and later effusion (Fig. 1054). There is tenderness between the fibula and the tibia in front, localized, dependent on some tearing of ligaments (Fig. 1055).

The bulk of the swelling and soreness is on the *outer* side, over the joint. Swelling may be great, and may be accompanied by much ecchymosis and by a good deal of tenderness localized below and in front of the external malleolus.

Diagnosis.—Diagnosis depends on the lack of deformity, of crepitus or abnormal mobility, in sprain, and on the presence, in the fibular

fracture, of tenderness localized somewhere on the subcutaneous surface of the bone, or pain on pressure on the malleolar tip.

In "sprains" the subcutaneous surface of the fibula is *not* tender, except at the point marked x in Fig. 1055.

The swelling of a sprain varies in exact location, not following the outline of any anatomic structures; in general, it lies about as sketched in Fig. 1053.

Sprains by other trauma than inversion show swelling elsewhere, of course, and do not show any *characteristic* types of swelling or of localized tenderness.

RESULTS OF FRACTURES THROUGH AND NEAR THE ANKLE-JOINT*

Apart from the stiffening effects of overlong fixation, the results are dependent on mechanical conditions.

In fractures involving the *ankle-joint* itself we have certain special

Fig. 1056.—Old backward luxation, with fracture of posterior edge of tibia.

factors bearing on the disability, viz.: Displacement of joint surfaces, including backward, forward, inward or outward dislocation; weakening or stretching of the ligaments; destruction, partial or complete, of the ankle-joint considered as a mortise, permitting abnormal lateral motion; irregularity of joint surfaces.

Displacement of Joint Surfaces.—*Backward* dislocation gives absolute loss of dorsal flexion and gives a weakened bearing surface to receive the astragalus and carry the body-weight. This is true whether the dislocation be a pure dislocation or whether a bit of bone be carried up and backward with the astragalus.

As the result of *forward* dislocation with fracture unreduced there is loss of most of the motion of the foot, a loss of power in the ankle due to a short leverage of the calf muscles, and a bearing surface at best

* For a fuller consideration of this matter see "Causes of Disability after Fracture of the Lower Leg and Ankle," F. J. Cotton, Trans. of the Massachusetts Med. Soc. for 1905, and Boston Med. and Surgical Journ., 1905, cliii, p. 263.

ill-adapted to carry the weight, sometimes no bearing surface worth mentioning opposite the astragalus. Moreover, no proper hold for the ankle-joint mortise can be afforded by the irregular and narrow surface of the back part of the astragalus.

Fig. 1057.—Sketch from a case of the writer's; fracture of back edge of tibia, with backward luxation. Increased distance from internal malleolus to heel. Old case, many months after injury.

Inward dislocation uncorrected, associated with the displacement upward of the internal malleolus, means a destruction of the mechanical solidity of the mortise. It means also inversion of the foot and a disadvantageous pull of the peroneal muscles, which might otherwise be relied on to correct this inversion.

In such cases the patient can usually walk on the foot after a while, but tends to walk on the outer side of it.

He is easily fatigued and very uncertain of his footing.

If there be persistent *outward* displacement we have the "static" trouble, to be considered later, but there may also be a lax joint.

Widening of the mortise between tibia and fibula has already been spoken of. Exactly how large a part it plays in disability is usually

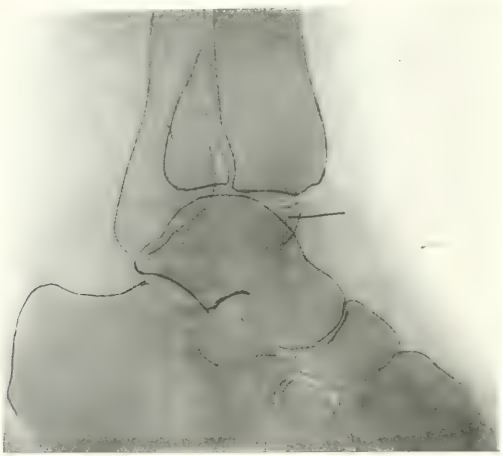

Fig. 1058.—*X*-ray of similar case and similar displacement as in Fig. 1057. Already consolidated (outlines reinforced).

hard to make sure of. That it does play a part is not open to question, for we see cases in which the outward rotation of the astragalus is obvious in the *x*-ray, a rotation made possible only by this widening (Fig. 1065).

Weakening of the ligaments is important as a result of true Pott's fracture (Fig. 1064). Its equivalent, lowering of the internal mal-

leolus during healing, has a precisely similar effect. (See Fig. 1063.) In either case the ligamentous support of the inner side of the foot is lengthened and lessened. This is the side of the foot that is subject to strain in ordinary use, and such weakening is very apt to favor, if it does not actually cause, the gradual development of flat-foot.

In neglected cases we may have absolute crippling.

Fig. 1059.—Anteroposterior view of same case shown in Fig. 1058 (outlines reinforced).

Fig. 1060.—Complicated fracture of lower end of tibia; old case. Massive new-bone formation in the region of 1 and 2; the fragment at 3 displaced *forward*, allowing luxation of the astragalus.

In properly supported cases the ligaments may contract later in the process of repair, and render any permanent support of the arch unnecessary.

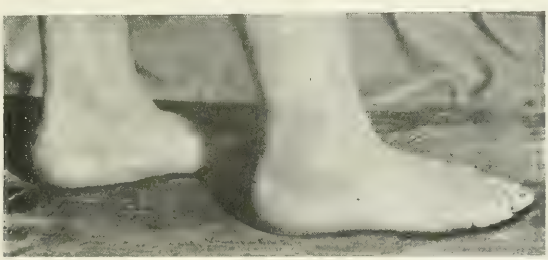

Fig. 1061.—Photograph of same case as shown in Fig. 1058. Shows thickening behind the ankle; does not show the luxation clearly. Operation in this case cleared away the obstruction caused by new bone. No attempt was made to reconstruct the joint; fair result.

There may be, on the other hand, a *permanent* lengthening of ligament with a *permanent* need for corresponding support.

Irregularities of joint surface do *not* mean ankylosis.

Ankylosis in the true sense does not occur so long as there is no lesion of the astragalus. Irregularities do, however, mean friction in the joint, and do result, in certain predisposed cases, in the occurrence of a "traumatic arthritis," with much consequent disability.

Fig. 1062.—Inverted Pott's fracture; same case as Fig. 1011 after operation; attempt to secure bony union and failure. Functional result slightly improved (*x*-ray 10687).

Apart from these disabilities, special to the fractures involving the joint itself, we have those common to *any and all fractures in the lower portion of the leg.*

It is my belief, based upon a special examination of some 50 odd cases of end-results carefully studied, and upon casual observation of many times this number, that the usual causes of disability in fractures in this region are largely *independent of the exact fracture lesions.*

They depend, in the main, on two factors—on deviation of the foot from the line of weight-bearing and on loss of motion due to stiffening of the joint structures, to excessive new-bone formation, or more usually due to muscle stiffening from long disuse, etc.

Shortening of the leg, under one inch, is ordinarily a negligible factor.

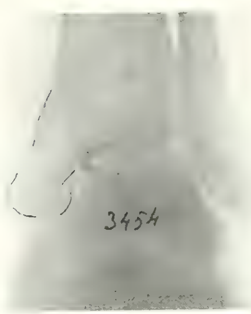

Fig. 1063.—Old case: Pott's fracture with the broken internal malleolus healed by bony union much longer than its original shape (outlines reinforced).

Fig. 1064.—Sketch from plate of an old Pott's fracture. Note the great rotation of the astragalus and its distance from the internal malleolus. In this case the deformity was progressive, dependent mainly on lack of ligaments. (Courtesy of Dr. G. H. Monks.)

To sum up this matter; so far as the question of malposition goes, we have four main directions of deviation, as shown in Fig. 1066.

Deviation of the foot *inward* means no strain on the arch, but does mean some added strain on the outer ligaments and the tendons above the ankle, and means an awkward gait with a considerable tendency to "inversion strain" of the ankle. Extreme deviation

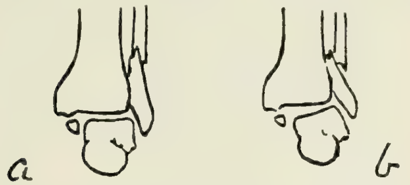

Fig. 1065.—Widening of mortise at ankle: *a*, Displacement without widening; *b*, displacement with the mortise actually widened.

Fig. 1066.—1, Backward bowing, the weight-bearing axis falls behind the heel; 2, it lies to the outer side; 3, to the inner side.

is crippling (Fig. 1062). Ordinary degrees cause simply some clumsiness of the gait or some tendency toward fatigue.

Deviation in the other direction *outward* is a very common cause of severe disability (Figs. 1067 to 1070).

Fig. 1067.—Sketch of Warren Museum specimen No. 1190. Plaster cast. Details of fracture not known; probably Pott's fracture, with extreme lateral and some backward displacement. This is a type of displacement that makes trouble.

Fig. 1068.—Outward displacement, due to displacement of fragments in ankle fracture. It will be noted here that there is no flat-foot and that the muscular power of the foot is obviously good. Author's case.

Even a deviation of the foot ¼ inch outward from its proper place means a distinctly increased strain on the muscles and other structures

Fig. 1069.—Outward deviation of the foot and consequent shifting of the weight to the inner side of the triangle of support.

Fig. 1070.—X-ray of same case as shown in Fig. 1069.

Fig. 1071.—Outward deviation of the foot; old ankle fracture. In this case the deviation is, in fact, due not so much to displacement at the fracture as to entire muscular insufficiency following the fracture, which has resulted in extreme flat-foot, with eversion. Operation without subsequent treatment with plates, exercises, etc., would be of very little use in this case.

Fig. 1072.—Same case as Fig. 1071.

that maintain the arch. So long as these muscles suffice for their work we have no necessary limp, and sometimes there is no disability. When they give way, we have the limp and disability and deformity characteristic of the strain, as in ordinary flat-foot, differing from static flat-foot only in that it is harder to remedy by support, owing to the mechanical disadvantage of muscle pull. Any considerable deviation in the outward direction due to fracture is, therefore, almost certain to interfere with a good result, and may give very bad results indeed.

Fig. 1073.—The triangle of support; broadly speaking, every strain of weight-bearing, the line of which falls outside or inside this triangle, represents an unnatural strain on muscles, etc.

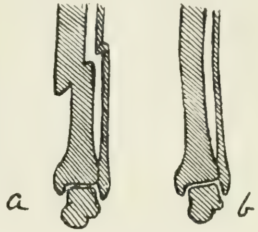

Fig. 1074.—Deviation of the foot outward. Different as they look, these forms of deformity involve *equal* strain at ankle and foot.

Forward displacement of the foot, that is to say, backward bowing near the joint, gives a mechanical disadvantage in propulsion, as is shown in Fig. 1076, and if the deformity is considerable it gives some awkwardness in gait. It may be a troublesome deformity, but is not crippling, as a rule.

Fig. 1075.—Considerable deformity at the site of the fracture. Not much displacement of the weight-bearing line. This foot is functionally perfect. Sketch direct from a case of the writer's.

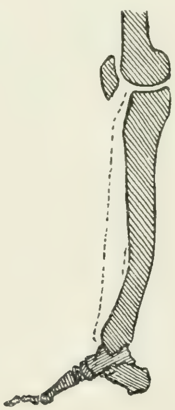

Fig. 1076.—Backward bowing; the handicap in propulsion depends on the fact that the weight-bearing line falls over the heel, not the ankle: the lift is greater, and a clumsy gait results.

Displacement of the foot backward (*forward* bowing) is unusual: it

does not seem, in the few cases observed, to be a factor in disability unless the joint is directly involved.

What the importance of *rotatory* displacement is it is hard to say. There seem to be no data except those of ordinary unrecorded observation, and I can only give my impression that a fracture that makes a foot "*toe in*" thereby conduces to an ungraceful gait, and that one which makes *toeing out* a necessity causes not only an awkward gait, but some increased tendency to flat-foot, as well as some mechanical loss of motor power.

More important even than the deviation in axis is the amount of *loss of joint motion.*

Loss of anteroposterior motion in the joint is the least troublesome

Fig. 1077.—Backward bowing of both bones, with forward displacement of the foot.

Fig. 1078.—X-ray plate of same case as shown in Fig. 1077.

defect. It may not uncommonly cause the formation of a habit of toeing outward, and eventually a flat-foot, from what the orthopedists call "metatarsal strain," but does not cause much direct trouble as a rule.

Loss of lateral motion, on the other hand, is a constant source of lameness. In the ordinary use of the foot the lateral motions (carried out between astragalus and os calcis, and in some measure at the mediotarsal joint) are the means whereby the foot accommodates itself to the inequalities of the ground on which we walk.* If such accommoda-

* For the mechanism of such accommodation, see R. W. Lovett and F. J. Cotton, Transactions Am. Orthopedic Assn., 1898, xi, p. 298.

tion is impossible, an enormous strain is thrown on shortened muscles and ligaments; they react in the way that such structures do react to overstrain, by producing lameness.

It is very common to find that a patient just recovering from an ankle fracture says that he can walk perfectly well in the house, but not without pain on the street, which is to say he cannot walk on any surface other than a perfectly level one.

During the first few weeks of repair the tendency is for limitation of motion to disappear under judicious movement. After a lapse of some months, however, fibrous changes have taken place, and the strain of attempted motion falls on rigid structures, which show little tendency to lose their rigidity.

Just what structures are involved in this stiffening is a matter of secondary importance. My notion is that shortening of muscles plays a very important part. We know that simple fixation of a sound limb causes little change in the muscles, little stiffness of the joint—often none at all.

With an injured limb, however, it is an entirely different matter. Just why this is so is unknown, but in case of fracture a very short series of observations will convince any one of the tendency to loss of motion in joints near the fracture. The nearer the fracture is to the given joint, the greater is this tendency. Such stiffening is greater in the aged, but occurs even with children. In children the tendency to permanent stiffness is practically *nil*, but temporary stiffening may take some months to disappear.

Fig. 1079.—Forward bowing. Obviously gives clumsiness of gait, though no great disability (diagram).

In healthy patients under thirty the stiffening is but moderate, and usually disappears in the main with time and use.

In older patients it is usually permanent, if once established, and not remediable by the use of massage.

How are we to prevent such loss of motion? Simply by not allowing it to establish itself. We have already learned to avoid stiff fingers in Colles' fracture, but seem to have learned little about stiff ankles. The method of avoidance is the same in one case as in the other—simply sufficient motion, begun sufficiently early to *prevent* stiffening.

Proper position is important, and fixation is necessary. We need not follow Lucas-Championnière and his school so far as to discard what we should regard as proper fixation, but we may remove fractures from the plaster for a few minutes every day (after ten days to three weeks) in order to insure the maintenance of supple joints by passive and by active motion. In the worst cases the surgeon may combat any tendency to displacement with his hands while such motions are carried out. The surgeon must be his own judge as to the danger of displacement in a

given fracture, and as to the possibility that motion may tend toward delayed union or non-union. I believe this latter possibility to be very slight. At all events, it is along these lines that we must combat the tendency to stiffening.

Golding-Bird and others have familiarized us with the alleged rôle of the projecting ("riding") fragment, and much ingenuity has been spent on proposals for combating local displacement. It is, no doubt, true that projecting fragments may be tender, and that "spurs" may require removal later. It is also true that marked displacement of bone-ends means slower union. It is true also that a union such as is sketched in Fig. 1080 may give persistent local pain, apparently from persistent weakness at the point of fracture, but, after a rather careful study of this point, extending over several years and many cases, I have failed to convince myself that a fracture such as is shown in Fig. 1075 or Fig. 1081 shows any more tendency to disability than one with good bony apposition, provided the original trauma, with its destruction of soft parts, is the same; provided, also, that the stiffening (from trauma plus fixation) is the same, and provided that in each case the foot is equally far removed *from its proper relation* to the weight-bearing *axis* of the leg.

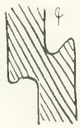

Fig. 1080.—Painful union. Ordinarily, considerable displacement gives no local pain after consolidation is complete; where, however, the mass of bone is relatively small, as, for instance, in such a case as is shown in the sketch, we sometimes get persistent sensitiveness and pain *at the fracture* on use (diagram).

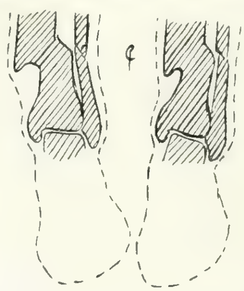

Fig. 1081.—The fracture sketched on the left gives a bad prognosis; that sketched on the right, apparently almost exactly similar, gives a good prognosis as to use because the general line of the shaft of the tibia is not disturbed in its relation to the foot; in the case shown to the left it is.

OPERATIVE TREATMENT OF ANKLE FRACTURES

Operative treatment will rarely be wise as a primary measure, save in compound cases: with proper treatment it will rarely be needed at all.

Old fractures, however, in which the result is bad, may often be improved very greatly by operation.

Particularly, deformed ankles from Pott's fracture or from inversion Pott's fractures are amenable to treatment.

For Pott's fracture the best operation (first done apparently by Stimson) is a cross-section of both malleoli *at the level of the joint* (see

(Fig. 1082), with cutting and tearing of the ligaments, until adduction of the foot is possible (Fig. 1083). The wounds are sewed up, and correction in sharp inversion is maintained by plaster. I have done this operation in a number of cases, always with an *improved result*, and often with very great improvement.

In *inversion* fracture the incisions are the same. The fibula is chiseled at the joint level, and, according to the solidity of union, the

Fig. 1082.—Lines of incision for bimalleolar osteotomy for correction of deformity in old Pott's fracture.

old fracture-line in the tibia is reopened, or the malleolus is chiseled across at the joint level. The foot is then reduced into the appropriate eversion position. If an old oblique fracture-line in the tibia has been reopened, it will be wise to *peg* the bones into place by a nail or drill (see Fig. 1084), to be removed after ten days to three weeks. Save for the chance of failure of union (in cases operated on for non-union), the operation is a satisfactory one.

Cases of backward or forward luxation with joint fracture may be

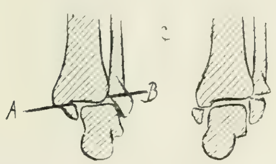

Fig. 1083.—Bimalleolar osteotomy for deformity in old Pott's fracture. A and B, the chisel cuts, are at the level of the joint surface. After the malleoli are cut the ligaments are torn to some extent by wrenching the foot, and then the astragalus and both malleoli are bodily carried inward until the deformity is corrected.

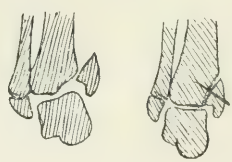

Fig. 1084.—Operation for inversion Pott's to correct displacement or failure of union. Broken surfaces are refreshed, the foot carried into abduction, and a nail driven in through the malleolus into the shaft. To be left in about three weeks.

operated on through similar incisions. Wide cutting and tearing of ligaments and much cutting of new bone are needed, but in the end the astragalus may be brought back to its normal place, and held there by a properly applied plaster.

These operations are very tedious and difficult, but the results are well worth the trouble. (See Fig. 1085.)

Operation for removal of bone-masses interfering with the tendons

behind the internal malleolus has been done by the writer in one case, with improved results. (See Fig. 1061.)

All these operations are done without drainage.

Fig. 1085.—End-results after operation, showing the range of motion. Case of fracture of tibia and fibula, with backward and outward displacement. Same case as shown in Figs. 1056 and 1068.

Early motion, passive and active, is called for.

The results, while rarely comparable to those of properly treated fresh fractures, are surprisingly good in the general run of cases.

CHAPTER XXX

ASTRAGALUS LUXATIONS AND FRACTURE

TOTAL LUXATION OF THE ASTRAGALUS

By this title is meant that form of luxation in which the astragalus is torn not only from its attachments to tibia and fibula, but from its relations to the os calcis and the scaphoid as well. It is displaced in one or the other direction, and usually rotated about its long axis. Not uncommonly it is fractured as well as displaced. The injury is often a compound one. There may be associated fracture of the fibula.

This luxation is a curious and unexplained sort of injury. The astragalus has no muscular attachments, but is the "block" of a sort of "block and pulley" arrangement, held in place by the tendons that run across it, as well as by strong ligaments. It must be "jumped" out of place by sudden one-sided strain. So far as case-histories go, the cause of the luxation seems to be the same sort of fall that gives the typical ankle fractures or the subastragaloid luxation.

Fig. 1086.—Dislocation of the astragalus inward (dislocated clear of both ankle and foot) (drawn from A. Cooper's plate).

Lesions.—The bone is torn loose from most, probably not from all, of its attachments. The question whether there are any attachments still left cannot be answered in a given case.

The lesion is often a compound one; when the displacement is inward, it must almost necessarily be compound, if not at first, then secondarily from sloughing, if not promptly reduced. Even with the head projecting on the outer side a sloughing of the integument seems inevitable if the tension be not relieved. The astragalus is a large bone, and the tissues about the ankle are tight.

The displacement may be *inward* or *outward*, with various rotations (there seems no fixed rule) on its long axis and also about a vertical axis.

Fracture of the bone may be associated. Most often it is of the

body rather than of the neck alone, and may be a splitting of the bone lengthwise.

Luxations *backward* are described, and said to be associated commonly with fracture of the neck of the astragalus.

Diagnosis. Both malleoli, whether intact or not, are substantially in their normal relation to the leg. The foot is displaced in or outward.

There is a mass in front of the ankle—to the outer side if the foot be swung in; to the inner side if the foot be displaced outward; the mass may have been displaced backward and be palpable at the back, leaving a hollow at the front. This mass is not in normal relation *either to the malleoli or to the bones of the foot below it.*

It may be directly recognizable by the "Saratoga-trunk" upper articular surface of the astragalus, with its well-defined edges (see Fig. 954); the other recognizable surfaces are the rounded head and the deep concavity which should articulate with the os calcis below and behind.

Figs. 1087, 1088.—Astragalus dislocated outward (*in toto*). Reduced by Dr. Lothrop later. There was later necrosis of part of the broken astragalus, and resection was done. (Courtesy of Dr. H. A. Lothrop.)

The presence of fracture may be indicated by crepitus. The situation of such fracture is not likely to be made out by palpation.

The x-ray may define any *fracture* present. Beyond this it is not likely to do more than confirm what we can feel.

Treatment.—Reduction of this luxation has not, as a rule, been brilliantly successful. Here and there the bone has been reduced. In some such cases one wonders if the luxation was not subastragaloid. Certainly there has been, as Hutchinson has pointed out, much confusion between these two forms of displacement:

The difficulties of reduction are:

(*a*) Lack of tendon attachments to pull on—and the small leverage for direct pressure.

(*b*) The presence of rotation *with* displacement.

(*c*) Entanglement of some of the many tendons that cross at this level.

(*d*) The not uncommon complicating *fracture*.

Reduction.—The manœuvers for reduction that have been approved may be summed up as follows:

Inward luxation. With the foot in slight plantar flexion.

Exert traction on the foot.

Swing it outward.

Make pressure on the prominent bone—shoving outward and back.

Modify pressure to correct any *rotation* of the bone.

Fig. 1089.—*X*-ray plate. Same case as Figs. 1087, 1088. It will be noted that the body of the astragalus has been broken in two.

Assist reduction by swinging and rotating the foot so as to manœuver any entangled tendons out of the way if possible.

Outward luxation—reverse the above motions:

Plantar flexion.

Traction.

Inward traction.

Inward pressure on the astragalus, etc.

Backward luxation:

Plantar flexion.

Traction downward.

Direct forward pressure on the astragalus.

Inversion of the foot.

Tenotomy of tendons (tendo Achillis or tendo tibialis postici) is said to be of assistance in these reductions.

In case of fracture with the dislocation these measures can hardly be modified more than to insure pressure on any projecting points during reduction.

We are to try these measures fully.

If reduction fails, what is next to be done? The question of open reduction by incision is forced on us in this instance by the grave probability of sloughing if nothing is done, to say nothing of poor function even if sloughing and infection are avoided.

It was long urged that in these cases the nutrition of the bone was so compromised that it could not live, and even for simple irreducible cases excision was *de rigeur*.

The exhaustive anatomic research spent on this question in the closet was, as usual, wasted. Recent cases have shown that if kept clear of infection the astragalus, even if broken as well as torn loose, will somehow get nutrition enough, at least in some cases.

Fig. 1090.—*X*-ray of the same case as Fig. 1091, years after excision of the astragalus.

In any ordinary case that cannot be reduced otherwise, open reduction is indicated; owing to the danger of sloughing, it should not be delayed. Today excision is not to be thought of unless infection or necrosis develop later.

In compound cases the problem is somewhat different. Here we must judge each case for itself. The displaced bone is viable only under favorable conditions in compound cases. Any considerable lapse of time since injury, a dirty wound, an enfeebled patient—any one of these factors may rightly, in the surgeon's judgment, justify primary excision of the astragalus in compound cases.

In this, as in all open reductions, drainage is assured by loose suturing only—the dressing is dry gauze, and the whole foot and lower leg go up in plaster, not to be disturbed until all reasonable chance of sepsis is gone by.

Within two weeks, unless there is associated fracture or cut tendons, massage and passive motion are begun.

In case of successful simple reduction without cutting, massage and passive motion are in place about the same time. Weight-bearing may

be postponed to four to five weeks. According to the nature of any fracture present, we must prolong fixation somewhat longer if there

Fig. 1091.—Views of foot shown in Fig. 1090, at present time, years after excision of astragalus. Fair function; same tendency to inversion of the foot; fibula prominent, sometimes painful from pressure of boot.

is a fracture of the neck than if there is a longitudinal split not tending to displacement.

Fig. 1092.—Another case of astragalus resection for dislocation. Function now perfect for ordinary walking—not even any limp perceptible as he walks on the street.

Results.—If the luxation is successfully reduced, the result is an approximately normal foot, whether the reduction was open or not.

Associated fractures increase disability, but apparently to a less extent than one would think. Expectant treatment, *if there is no sloughing*, may be not altogether bad, as the following case* shows:

C. E. C., aged fifty-five, entered the Boston City Hospital for treatment of an old injury of the ankle received several years previously. He could walk, but his toes were contracted and the ankle thick on the inner side. He had no pain in treading on the heel, but much pain on putting weight on the toes. There was a hard, irregularly rounded mass, "including the lower end of the tibia and running backward." Operation showed this mass to be the astragalus so rotated that the upper articular surface looked inward. No reduction was attempted.

Expectant treatment, where sloughs occur, means secondary excision, safer as to life perhaps than the primary incision, but no better in functional result.

Excision of the bone, much vaunted, seems to me very undesirable; plates herewith given show skiagraphs of one case in which function after excision is excellent; a second case in which permanent partial crippling was the result. Like cases are recorded here and there in the literature. The operation, at its best, gives a foot that can be used, but the joint is between the ankle mortise and the back part of the os calcis—with nothing to prevent rolling of the foot and no firm purchase,† results to make us shun the operation if it can be avoided.

Fig. 1093. Fracture of neck of astragalus (see explanatory sketch in upper right-hand corner).

ASTRAGALUS—FRACTURE

Fractures of the astragalus are to be classed as:

(*a*) Fractures of the neck.

(*b*) Fractures of the body.

Fractures of the neck are, in the rule, approximately transverse. They result from cross-breaking "shearing" strain, rather than from crushing, and are in many cases the result of falls on the feet. Where we find, as in the case shown in Fig. 1097, for instance, a fracture of the astragalus on one side, of the calcis on the other, the presumption is that the astragalus breaks if the ball of the foot, not

* Courtesy of Dr. George W. Gay, reported from the Boston City Hospital records.

† Probably if excision seems unavoidable, wise surgery would dictate fitting the end of the tibia to the space left by the astragalus, after denuding all surfaces of cartilage and periosteum, and trying for a stiff ankle, with the alternative of amputation at the point of the election if the result of excision proves poor.

the heel, receives the force. Direct proof of this is lacking. This fracture is said by Helferich to occur alone only rarely: all cases I have

Fig. 1094.—Fracture of neck of astragalus. Drawing from x-ray plate of left foot in the same patient whose right foot is shown in Fig. 1093. In neither case, right or left, was there any considerable displacement of fragments

Fig. 1095.—Fracture of neck of astragalus, with displacement of the head upward (the arrow at the back shows the "apophysis" broken loose also).

Fig. 1096.—Fracture of neck of astragalus; see light line running down and back from the point of the arrow. No displacement; solid union; good result.

seen have been uncomplicated, and there seems no other authority for the statement.

Fractures of the Neck

The displacement is typically of the head upward, but not far upward.

Diagnosis.—There is total disability. There is swelling. There is no marked deformity, as a rule. There is local tenderness on pressure.

Fig. 1097.—Fracture of the neck of the astragalus in a boy of about eleven years (case seen by courtesy of Dr. E. G. Brackett) (*x*-ray by A. W. George, M.D., outlines reinforced).

Fig. 1098.—End-results in case seen in Fig. 1097. Perfect motion and function three years later. Nothing to show for fracture except slight local thickening.

There is filling up of the hollow at the outer side of the neck of the astragalus—thickening in the "sinus tarsi." There is crepitus, readily obtainable on lateral motion. There is pain on motion, most marked in dorsal flexion.

Treatment.—Treatment consists, obviously, of the best possible replacement of fragments and of fixation. To secure and hold this replacement it is wise not to be too literal about maintaining the traditional right angle at the ankle-joint. Any plantar flexion resulting can be corrected later.

Fig. 1099.—This sketch (after Luxembourg's plate) shows fracture *with rotation*, a much more serious lesion than the usual form shown above, and requiring much care, perhaps needing operative reduction.

Fixation is continued until the consolidation is at least tolerably firm; after this, massage and passive motion are in order. The bone is not fit to bear weight for many weeks; there are no exact data, but eight weeks is hardly too long.

Excision of a part or the whole of the bone is only to be considered in unfavorable *compound* fractures. I suspect it is likely to be unwise as a primary measure, even in these cases, if the wound can be made reasonably clean.

Prognosis. Unlike some other tarsal fractures, this break, lying in

the main *between* two joints, seems to unite by bone. With decently accurate replacement the results are excellent. There is a minimal loss of motion, but practically perfect function of the foot.

Fracture of the Body of the Astragalus

Unlike the fractures of the neck, the fractures of the body follow no type. They may be transverse, longitudinal, or irregular crushing fractures.

Diagnosis.—The diagnosis is apt to be vague unless there is associated dislocation. Crepitus and localized tenderness may help us as to the presence of fracture, but accurate detailed diagnosis of the fracture, even if there be sharp separation of fragments, is rarely possible except through the x-ray, not always then.

Treatment.—The best possible reposition of fragments, and fixation, are the obvious indications. This means reduction by traction and direct pressure, fixation in a position of very slight plantar flexion in plaster-of-Paris for a matter of four to six weeks, then massage and passive motion, with gradual resumption of use, but no weight-bearing until after six weeks, at least.

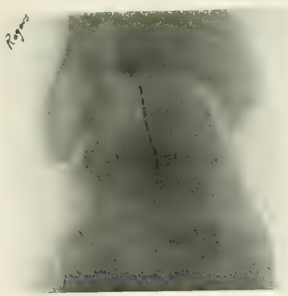

Fig. 1100.—Fracture of the body of the astragalus. The dotted line shows the line of fracture, visible in the plate, but not in the print. There was no displacement. The diagnosis was made on the basis of disability and sharply localized tenderness (case seen with Dr. Brearton, Dorchester, Mass.; x-ray by H. F. R. Watts, M.D.).

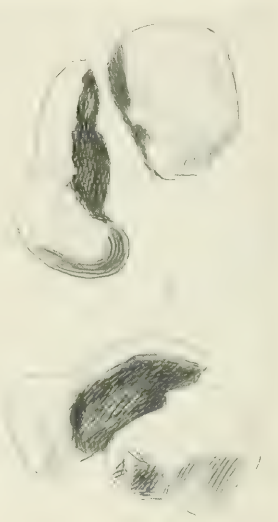

Fig. 1101.—Longitudinal fracture of the left astragalus. Autopsy specimen. Sketched by courtesy of Dr. T. Leary. (Seen from above and from the outer side.)

Prognosis.—There seem to be no data available bearing on prognosis. The assumption is apparently that prognosis is favorable. I have no reason to doubt it. The very few cases I have seen have gotten good results.

CHAPTER XXXI

LUXATIONS BELOW THE ASTRAGALUS

These are to be divided into two classes—dislocation of the foot as a whole below the astragalus, including the os calcis, and the dislocation at the mediotarsal joint, with the calcis still in place.

SUBASTRAGALOID LUXATION

(Luxation of the Foot, including the Os Calcis, beneath the Astragalus*)

Considering the strength of the calcaneo-astragaloid ligaments, this luxation seems well-nigh impossible, yet it occurs, and is not even very

Fig. 1102.—Subastragaloid dislocation of the foot inward, a few hours after injury. Injury received in a runaway accident. Reduction proved impossible; the astragalus was excised. The illustration is drawn from a faded, though originally excellent, photograph (now about ten years old), kindly placed at my disposal by Dr. Wm. P. Bolles.

rare.† The forces causing it are the usual causes of ankle damage, inversion or eversion of the foot, usually under the body-weight in falls.

The dislocation may rarely be complicated with fracture. MacCormac and Pollock report cases complicated with fracture of the neck

* First adequately described by Broca (1853) and Henke (1858).

† According to Trendel (Bruns' Beiträge, 1905, xlv, p. 360), of Bruns' clinic, this is the rarest of the dislocations involving the astragalus, occurring but once in ten years in Bruns' large clinic, and reported but once in thirty years of reports of the German army. Trendel has, however, collected 82 cases—40 of *inward* luxation, and in a limited experience I have met with three.

of the astragalus, but the lesion is ordinarily uncomplicated. It may be compound, but not often. The displacement of the foot may be inward or outward, forward or back.

Fig. 1103.—From below (diagram). The foot, unchanged in length or shape, is tilted inward (or outward) under the stationary leg and astragalus (compare with Fig. 1105).

Fig. 1104.—Subastragaloid luxation of the foot outward (sketch after Jeney's plate).

Diagnosis.—The astragalus is in normal relation to the malleoli. The head of the astragalus projects inward or outward, not covered by or in contact with the scaphoid. The foot is displaced and rotated inward or outward, as may be. The calcis is not in its normal relation to the malleoli, but is twisted in the same direction as the rest of the foot.

Fig. 1105.—Subastragaloid luxation. Note that the *heel is displaced*, with the rest of the foot, inward. This case was readily and perfectly reduced (courtesy of Dr. L. R. G. Crandon).

Fig. 1106.—Subastragaloid dislocation inward (service of Dr. F. S. Watson; patient refused any treatment) (print given me by Dr. A. Fraser).

The sustentaculum tali may be palpable in cases with inward displacement, according to Stimson. The determination of the position of the os calcis is by no means easy, especially in a fresh case with swelling, and the distinction of this form from the mediotarsal luxation

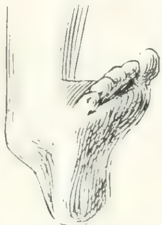

Fig. 1107.— Subastragaloid dislocation of foot inward. Drawn from a sketch in the old records of the Boston City Hospital.

Fig. 1108.— Subastragaloid luxation of the foot up and outward (sketched from Wendel's x-ray).

Fig. 1109.— Subastragaloid luxation of foot backward (sketch from Luxembourg's x-ray plate).

is not simple. Fracture of the neck of the astragalus with displacement of the head may give a not dissimilar picture, though crepitus should be obtainable.

The writer has seen two such cases recently with luxation *inward,* both showing the same clinical picture, both caused by falls in which

Fig. 1110.—X-ray view of same case shown in Fig. 1105 (rights and lefts are reversed in comparing Figs. 1105 and 1110): 1, 1a, Astragalus; 2, os calcis; 2a, scaphoid (outlines reinforced).

the foot was turned inward. The general appearance of the foot is not unlike that of the so-called "inversion Pott's." The internal malleolus is no longer prominent, the external is unduly prominent. The sole of the foot faces inward, and any correction of displacement is impossible.

The diagnostic points are as follows: The upper edge of the astragalus may be felt just in front of the fibula, the outer side of the head of the

Fig. 1111.—Subastragaloid dislocation of foot inward. Case readily reduced (sketch from a case of the writer's).

Fig. 1112. Reduction of subastragaloid luxation inward. The astragalus is held fixed by the hand, as shown; then the foot is carried inward and swept outward in the direction indicated by the arrows. This reduction was used in cases shown in Figs. 1105 and 1111.

astragalus is extra prominent* at about its normal position; the scaphoid is to be made out near the position of the internal malleolus, a little in front, and the distance between the tubercle of the scaphoid and the outer side of the astragaloid head is increased. The os calcis

* There is, with the inward luxation of the foot, some forward and *outward* displacement of the astragalus—*sub*luxation—in the mortise.

is tilted out of its usual position and *inclined* inward. Its total *displacement* inward is slight.

There is no interference with the up-and-down motion in the ankle-joint proper. There is, of course, total disability so far as use of the foot is concerned.

Reduction of Inward Luxation. An assistant grasps the ankle

Fig. 1113.—Reduction of luxation of foot forward under astragalus (diagram).

firmly while the surgeon grasps the heel with one hand, the dorsum of the foot with the other, and makes strong traction in the line of the axis of the leg. Then the foot is adducted slightly, without letting up on the traction, and then is swung strongly outward. Reduction occurs with a snap. In one case, owing to the slight mobility of the astragalus laterally, it was found necessary for the assistant to fix the head of the astragalus with his thumbs, in order to hold this portion of the foot firm enough to facilitate reduction (Fig. 1112).

Fig. 1114.—Subastragaloid luxation backward. Grip for reduction. Plantar flexion, forward pull, countertraction.

If this does not work, circumduct in both directions in hope of clearing any tendons that may be caught, and then repeat the attempt.

For the *outward* displacement the motions are simply reversed.

This method, or even simple traction and direct pressure, is usually efficient in reduction.

If the dislocation is otherwise irreducible, open incision is fully justified. Through an incision, reduction over blunt levers is relatively a simple matter. Moreover, entangled tendons can be dealt with. Compound luxations are obviously not to be experimented with long before open reduction is resorted to.

Inasmuch as the astragalus in this lesion still retains its connection with tibia and fibula, it is a question if primary excision of the astragalus is ever called for.

Prognosis.—Once reduced, this injury gives little trouble and seems not even to weaken the foot materially. The period of disability in some cases is only a couple of weeks or so.

The following is apparently the only instance showing any possibility of recurrence:

Fig. 1115.—Subastragaloid luxation outward. Grip for reduction; traction downward, combined with adduction of the foot.

F. W., aged thirty-seven; acrobat; of alcoholic habits entered the Boston City Hospital October 31, 1890, with a "partial" luxation of the right astragalus; this was reduced under ether; he went out in a week. Two days later he came back, the joint was again dislocated; this time the displacement was of the foot outward; reduced; went out after two days against advice.

October 17, 1891, reëntered; luxation of astragalus forward; reduced; went out after two days.

April 14, 1892, reëntered with luxation of foot inward beneath the astragalus; reduced; went out after two days; the same night back again with the dislocation reproduced as result of a fall. This was reduced; he left and did not reappear.

In one of the rare cases of this sort in children is one recorded of a lad of five years in whom some slight permanent projection of the head of the bone resulted after successful reduction.

Ordinarily, however, these cases do perfectly well.

As to the results of this lesion, if unrecognized and unreduced, there seem to be no data. Obviously, there must be marked permanent varus (or valgus) deformity and much loss of function.

LUXATION AT THE MEDIOTARSAL JOINT (DISPLACEMENT OF SCAPHOID AWAY FROM THE ASTRAGALUS, OF THE CUBOID FROM ITS ARTICULATION WITH THE OS CALCIS).

This lesion occurs from forces apparently like those that produce subastragaloid displacement. The two lesions are about equally uncommon. The lesion under consideration is usually a displacement of the scaphoid inward and necessarily downward, or upward.

Associated with this is a luxation, or a subluxation, of the cuboid inward and up (or down) from its articulation with the os calcis. There is marked adduction of the front part of the foot. In all the few cases I have seen the displacement has been uniformly inward, in the varus position; the reverse deformity is said to be rarer, but does occur.

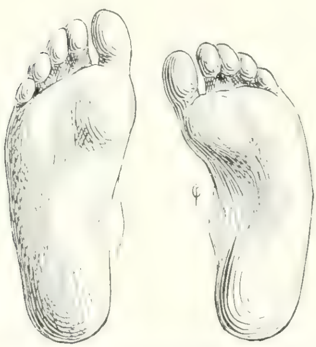

Fig. 1116.—Mediotarsal luxation from below (diagram). Note that the heel is *not* displaced; the foot *is* shortened; adduction and inward rotation of the front part of the foot are evident.

Fig. 1117.—Complicated fracture luxation of tarsus. Luxation of scaphoid and cuboid up and backward. Crushing of os calcis and astragalus; 1, cuboid, 2, third cuneiform (Warren Museum, specimen 6584).

The clinical picture is exactly similar to that of subastragaloid luxation in all respects except for the lack of inclination of the os calcis inward, a point not always easy to determine. The cuboid is separated from the os calcis and subluxated or luxated inward, but in the cases seen by the writer it has not, curiously enough, been possible to feel any definite prominence at the anterior end of the os calcis. This means

(and the x-ray confirms it) that the luxation at the outer side of the foot is incomplete.

Diagnosis.—Adduction (or sharp abduction) of the whole front of the foot.

Fig. 1118.—Mediotarsal luxation, one year after accident. Adult woman. Walks almost without limp, but uncertain and apt to fall. Curiously enough, the heel in this case is somewhat inverted, giving a picture here very similar to that of subastragaloid luxation (compare Fig. 1105).

Normal relation of the os calcis to the malleoli.

Fig. 1119.—Same case, seen from below. I cannot see that this shows anything save slightly greater inversion of the whole right foot. There was singularly little deformity in this case.

Normal motion in ankle flexion and extension, with loss of lateral motion and of rotation.

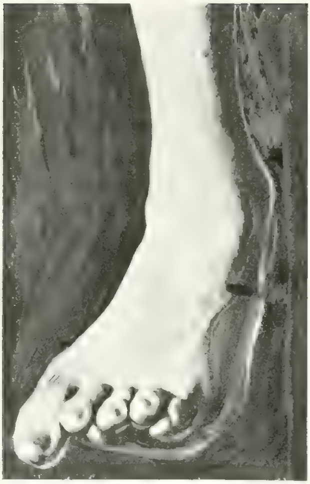

Fig. 1120. Mediotarsal luxation in a boy, three years after the accident. Walks with much limp.

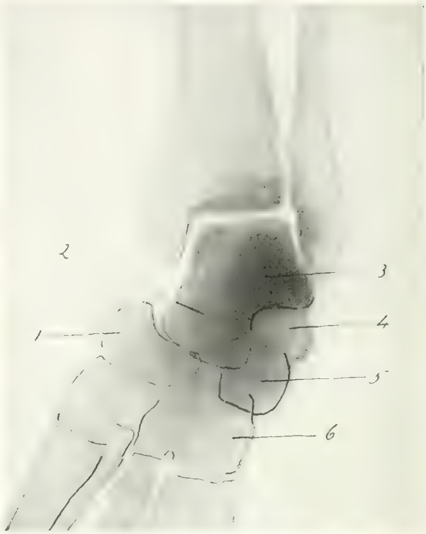

Fig. 1121.—X-ray of same case *mediotarsa luxation;* 1, Scaphoid; 2, astragalus (head); 3, astragalus (body); 4, os calcis; 5, front end of os calcis; 6, cuboid.

Fig. 1122.—X-ray, side view of same case. 1, 1′, 1″, 1‴ give outline of displaced scaphoid; 2 is the head of the astragalus.

Obvious prominence of the head of the astragalus to the outer side.

Shortening of the foot, present in *none of the other lesions so far described.* (See Fig. 1116.)

Varus deformity of the *whole* foot, seen from below, less marked than in any of the previous forms (Figs. 1118 and 1119).

Treatment.—Reduction in the fresh case is simpler than with the other forms of tarsal luxation. The front part of the foot is firmly grasped with both hands (see Fig. 1123) while the assistant steadies the ankle, with a thumb on the astragalus. Traction down and inward, with some plantar flexion, is then made on the front of the foot, and then it is swung out and upward, attention being paid to lifting the scaphoid

Fig. 1123.—Mediotarsal luxation. Grips and lines of force for reduction.

Fig. 1124.—End-result after operation on the case shown in Fig. 1120. The head of the astragalus was partly resected before reduction was possible. Function much improved. Still some stiffness from shortened tendons and muscles, which will improve.

into its place on the astragalus—the cuboid takes care of itself. The foot is ready for some weight within three or four weeks. With reversed displacement reverse the manœuver.

Results.—Inasmuch as none of the strong ligaments of the foot are usually torn in this luxation, it involves no weakening of the arch.

With early reduction the foot is substantially undamaged and is soon fit to use. In the old unrecognized unreduced cases the foot can be used, but is distinctly a clubfoot in shape and use, carrying the weight on the outer side of the sole, and having very little useful motion of any part.

Late Reduction by Operation.—The writer recently had an opportunity to observe the result in an old unrecognized dislocation of this

sort of a year's duration in a woman of forty-two years. There was marked inversion of the foot, with entire inability to evert, but the foot was perfectly capable of bearing weight and was painless, giving, however, much clumsiness in gait and a good deal of uncertainty, because of the liability of the foot to tip over when walking on an uneven surface. Operation by open incision was resorted to, and reduction effected without great difficulty. The results of this operation were excellent with the sole of the foot no longer turned inward, and with lateral motions possible to about half the normal range. (See Fig. 1118.)

In inveterate cases this form of luxation gives a chance of marked shortening of ligaments and tendons. I have operated on one such case of a duration of three years in a boy of twelve years, and found this the

Fig. 1125. *Sub*luxation of scaphoid inward. Case of writer's (outlines reinforced).

Fig. 1126. Apparent subluxation of scaphoid inward. This is, in fact, an *x*-ray of a perfectly normal foot in which the scaphoid tubercle is prominent.

principal difficulty, calling for a good deal of cutting of ligaments and for some sacrifice of bone from the astragalus. Reduction was accomplished, and the end-result was very satisfactory, with moderate motion preserved. (See Figs. 1120 and 1124.)

Subluxation.—The writer has seen one case in which there was a *subluxation* in this joint (rotatory up and in, with the cuboid in place), with displacement of the foot inward, shown clinically and confirmed by the *x*-ray. The patient left the hospital to return in a couple of days for reduction, but did not reappear for a month. During this period he had begun to walk, and the displacement had partially corrected itself. He did not recall any sudden snapping back. Further treatment was declined. Function was good and was improving (Fig. 1125).

CHAPTER XXXII

FRACTURE OF THE OS CALCIS

This is by far the commonest injury of the tarsus, and is, at least in the practice of the larger metropolitan hospitals, a not uncommon fracture.* There are three forms of this fracture, the one in which a part of the bone is carried away by strain thrown on the tendo Achillis, a form in which the bone is simply crushed, and a third form, the fracture of the sustentaculum tali.

The majority of these cases, in fact an overwhelming majority, belong to the second class—the class in which there is a more or less formless comminution of the bone as a whole; this is usually the result of a fall upon the feet from the top of a building, from a ladder or from some other height.

A similar form of fracture may rarely occur from a simple slip and twist of the foot. I have seen one case in which there seems to be no doubt that the fracture was produced in this way.

Lesions.—The comminution in these cases has certain relatively constant characters. The bone is broken through in something near a vertical plane, just in front of, or through, the posterior articulation between the astragalus and calcis. From this vertical line of fracture there is apt to be another line, running backward more or less horizontally, but not completed as a single line of fracture. It runs off into irregular planes of fracture at the back end of the bone, planes not always shown in the skiagraph. The outer side of the bone, which has a considerable cortical layer, seems to be *constantly* split away from the rest of the bone as a sort of plate (Fig. 1127).

As might be expected from the violence which produces the fracture, what is left of the back end of the bone is pushed—one cannot say displaced, in any exact sense—upward and not infrequently more or less outward as well. (See Fig. 1128.) Sometimes there is a distinct tilting *downward* of the forward end of the posterior fragment. There is apt to be some *diminution of the total depth* of the bone, especially at its forward end. The irregularity of the comminution in these cases may be judged from the fragments pictured in Figs. 1128 to 1148. Fig. 1127 was a case primarily differing in no way from those we usually see, in which the specimen was obtained after amputation, the amputation

* For additional data the reader is referred to Fractures of the Os Calcis, F. J. Cotton, and Louis T. Wilson, Boston Med. and Surg. Jour., October 29, 1908, vol. clix, No. 18, pp. 559–565.

being rendered necessary by sepsis introduced through a slough. It will here be seen that it is useless to speak of typical fracture lines in such cases.

It is, however, true that the general situation of the fractures ap-

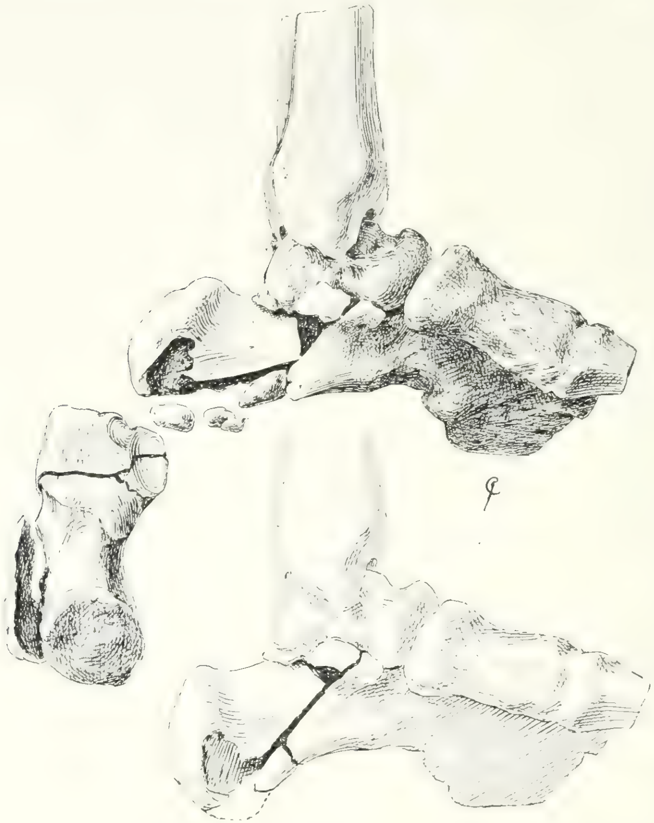

Fig. 1127.—Drawings from a specimen of fresh fracture of the os calcis from the author's collection. This was originally a simple fracture of the os calcis of the ordinary type; a skin slough developed, with subsequent sepsis of bone, necessitating amputation. The upper sketch shows the bones as they appeared after maceration; some bone splinters were missing. The os calcis, as a whole, was much displaced upward and outward; the lower sketch shows a reconstruction of the bone, showing fracture-lines; there was irregular splintering in the region of the inner tuberosity, and a fracture-line running through the sustentaculum; the sketch to the left shows the os calcis from above, the last-named fracture-line appears, splitting the sustentaculum; another fracture-line branching from it entirely separates the back half of the sustentaculum; an irregular fracture-line separates the thick cortical plate of the outer side of the bone for a considerable distance. It is not believed that there is anything typical about this fracture-line, as will presently be shown; the x-rays seem to show all sorts of irregular, complicated lines of fracture. I believe, however, that the damage in this particular case is not more than in the cases we are in the habit of seeing.

proximates that given above, as is illustrated in the x-rays given herewith. Only very, very rarely do we find approximately transverse fractures across the neck of the bone, behind the joint surface. (Fig. 1156 was a case of this sort.)

Even more rarely do we find fracture by avulsion. (See Fig. 1153.)

In one case was observed a loosening without displacement of the epiphysis of the os calcis from a fall on the foot.* (See Fig. 1154, for the relations of the epiphysis.)

Symptoms.—As a rule, the patient, after receipt of this injury, is unable to walk at all. He naturally cannot walk on his heel, and,

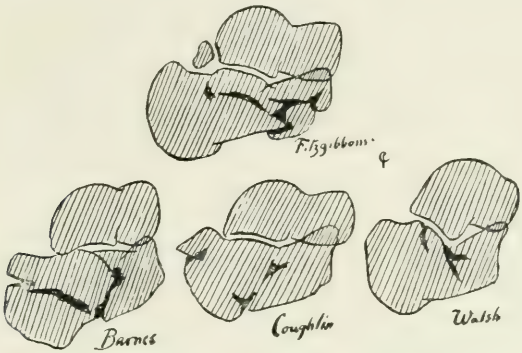

Fig. 1128.—Sketches from *x*-rays in author's collection—fracture of os calcis of various types or lack of type. The upper figure shows fracture of the "apophysis" at the back, also.

owing to the strain put on the bone by the tendo Achillis in such attempt, he cannot walk even on the ball of the foot. I have seen one patient who could walk, but this was a case of comparatively very little displacement with solid impaction.

Swelling in these cases is usually prompt, but not extreme. Pain is constant, but not especially severe.

Fig. 1129.—Rocklin (R.).

Fig. 1130.—Rocklin (L.).

Fig. 1131.—Kuntz (R.).

Fig. 1132.—Kuntz (L.).

Figs. 1129–1132.—Sketches from *x*-ray plates in fracture of the os calcis.

Diagnosis.—Curiously enough, no symptoms are ordinarily given in the books by which we may recognize this fracture, excepting crepitus and broadening of the heel.† There is, *in fact*, no difficulty about the diagnosis, and ordinarily it can be made in entire independence of the

* Case of Dr. Walter M. Boothby.

† Helferich does recognize the loss of lateral motion.

skiagraph. The swelling and thickening lie entirely *behind* the mediotarsal joint. There is thickening both to the inner and outer side of the foot. The malleoli are in their normal position and relation, and

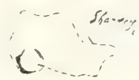
Fig. 1133.


Fig. 1134.


Fig. 1135.

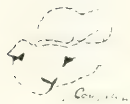
Fig. 1136.


Fig. 1137.

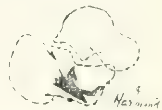
Fig. 1138.


Fig. 1139.


Fig. 1140.


Fig. 1141.


Fig. 1142.

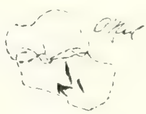
Fig. 1143.


Fig. 1144.

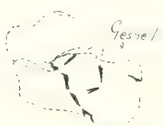
Fig. 1145.


Fig. 1146.

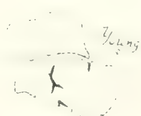
Fig. 1147.


Fig. 1148.

Figs. 1133–1148.—Sketches from *x*-ray plates in fracture of the os calcis in the author's collection.

there is little, if any, interference with flexion and extension in the ankle-joint proper. There is in many cases limitation, *often absolute*, of the lateral motions of the foot. In the presence of a swelling (almost

always at hand) it is hard to say whether upward displacement or outward displacement of the heel is present unless it is extreme. There is commonly the *appearance* of a shortening of the backward projection of the heel, but this is deceptive; such shortening may be

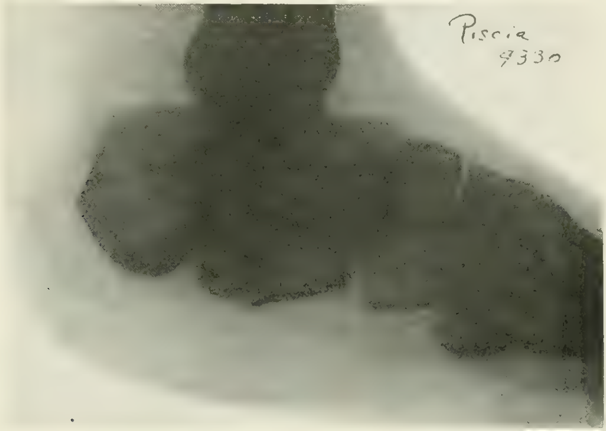

Fig. 1149. x-ray of fracture of the os calcis; unusually great displacement of the posterior portion upward and forward (shortening of heel).

present (Fig. 1149): there is usually little or no shortening of the foot as a whole to be made out by measuring or shown by the x-ray. On palpation we find more or less thickening below and behind the internal

Fig. 1150.—Fracture of os calcis; front split away from back portion; not very much displacement.

Fig. 1151.—Fracture by avulsion. The upper portion of the back of the os calcis is torn away by the action of the gastrocnemius and soleus muscles acting through the tendo Achillis; this is, in fact, a very rare lesion (this figure sketched after an x-ray plate by Branco).

malleolus, and below the *external* malleolus there is *always* a considerable thickening, giving commonly an entire loss of the projection usually shown by the external malleolus itself.

On closer examination we find that this thickening below the mal-

leolus is not soft swelling, but an obviously *bony* thickening. It is, in fact, the bone-plate of the outer surface of the bone, forced outward by the spreading of the bone beneath it. (See Fig. 1127.) This one sign seems to be nearly pathognomonic of this fracture. For two years past I have tested it on a large number of cases and have failed to find it only in one case where there was a fracture of the os calcis, this being a case shown by the x-ray to be atypical and without comminution. If we find this *bony* thickening in a case in which a fall upon the foot has been followed by disability and swelling below and behind the ankle, there need be no doubt about the diagnosis.

Fig. 1152.—Fracture of the os calcis by crushing in a child of four. The astragalus and os calcis are shaded. In the upper corner are shown the astragalus and os calcis from another plate of this same case. The result in this case was perfect function and very little thickening. Case unusually young for this fracture (sketch from x-ray plate). Courtesy of Dr. Thomas F. Leen.

If, in addition to this, we find marked *loss of the lateral motions of the foot*, we may say not only that there is a fracture of the os calcis, but also that this fracture has in some way involved the joints between the astragalus and the os calcis. This sign seems to be perfectly definite in those cases in which this is the only motion which is limited. In some cases this results from direct smashing into the joint (Figs. 1139, 1142, 1145, and 1150) between the astragalus and the os calcis (the rear joint, for there are two; for this joint see Fig. 1127), or it results from such general change in the shape of the bones as interferes with the action of the joint (as, for instance, in the case shown in Fig. 1139).

The x-ray is of decided value in these cases, but not for the purpose of diagnosis of the gross lesion so much as to give us information as to the amount of displacement. For this purpose x-rays should *always* be taken *of the sound foot*, as well as of the injured one (Figs. 1160, 1161). With the great variations in the shape of this bone in different individuals, it is only in this way that we can form any idea of the amount of distortion. It is not at all uncommon for *good* house officers in the hospitals to overlook this fracture, even where the skiagraph is at hand, for the fracture-lines are very often not obvious.

Treatment.—Inasmuch as the fragments in this form of fracture are usually entangled so as to fix them, even if there is no real impaction, the question of treatment becomes one of determining which cases call for reduction and which will do well enough if simply fixed and allowed to consolidate. There are a fair number of these cases in which the displacement is not very great, and in which pretty good results may be

obtained by simply putting them up in plaster until union takes place.

This does not mean, however, that this should be, as it has usually

Fig. 1153.—Normal epiphysis of os calcis. Apt to be confusing if not borne in mind.

been, the routine treatment. A consideration of the results of routine treatment, to be cited later, leaves no doubt that in most of these cases

Fig. 1154.—Old case; fracture of right os calcis in boy of thirteen, two years after fracture. Note broadening of heel and prominence of peroneal tubercle to the outer side of the os calcis.

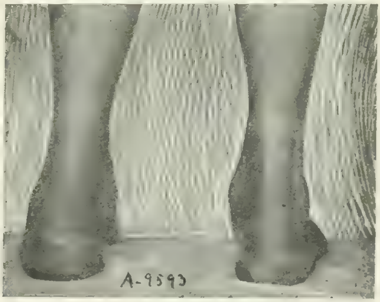

Fig. 1155.—Crushing fracture of left os calcis. Note broadening below malleoli on either side of the tendo Achillis, as compared with the sound foot.

we should *try* for an *improvement of position*, more particularly as there seems to be no possibility of making things any worse.

Within the past four years my own rule has been that cases that showed an obvious deformity or loss of motion—cases in which the skiagraph showed more than perhaps a quarter of an inch displacement—cases in which the x-ray showed spurs likely to make trouble by pressure in the sole or elsewhere (Fig. 1164), and cases in which the projection beneath the external malleolus was really considerable, should all have an attempt made to improve the position under ether.

Fig. 1156.—Sketch from x-ray plate of previous case (Fig. 1155). Os calcis flattened; fracture-lines rather irregular.

The method of going about to obtain such improvement is as follows:

The patient is fully anesthetized, the foot is brought into plantar flexion so as to relax the tendo Achillis, and the os calcis is grasped firmly just in front of the tendo Achillis, and an attempt is made to drag it downward. If this fails, as it usually does, on account of the difficulty of securing a sufficient grip, we attempt to break up the impaction by a lateral rocking movement and then bring the bone downward after the fragments are loosened. If this does not work, there is one method, which sounds very radical, but is really perfectly safe and simple,* by which we may attain the desired result. After disinfection, we make a small hole in the skin just in front of the tendo Achillis, on

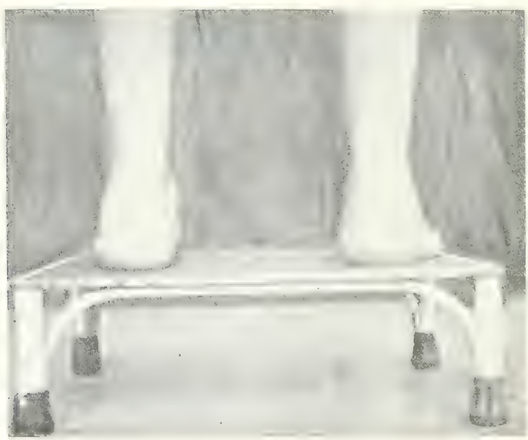

Fig. 1157.—Fracture of both ossa calcis, one year after accident.

both outer and inner sides, and then thrust a steel spindle (most conveniently a sound of about 22 caliber, French) through from side to side in front of the tendo Achillis (Fig. 1162). With this grip there is no difficulty in bringing the bone down where we want it, at any time within a week or so of the injury.

* Cotton and Wilson: Boston Med. and Surg. Jour., October 29, 1908.

When the position has been corrected, there is little tendency to redisplacement unless the ankle is dorsally flexed.

We next test the lateral motion and make sure that pronation and

Fig. 1158. Same case as Fig. 1157. Fracture of os calcis on both sides, with much displacement.

supination (lateral rotation of the foot) can be fully carried out. If necessary, we force these motions to their limit before being satisfied with the condition of things.

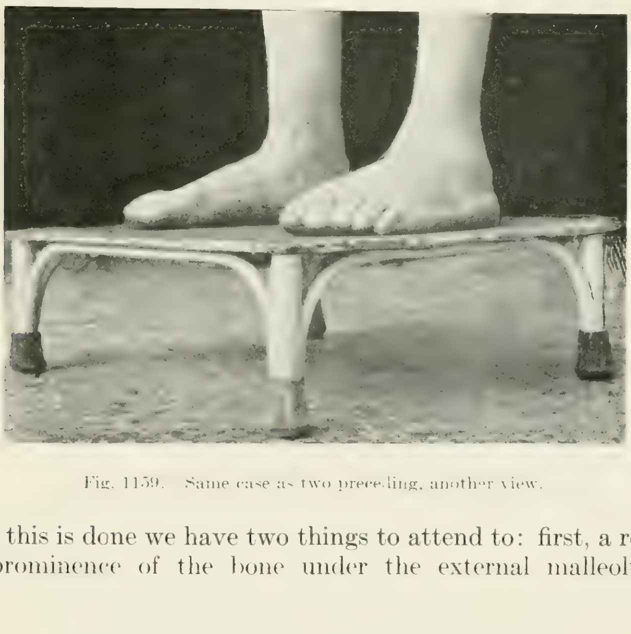

Fig. 1159. Same case as two preceding, another view.

After this is done we have two things to attend to: first, a reduction of the prominence of the bone under the external malleolus, and,

second, the best possible securing of impaction of the various fragments. Both these objects are secured by strong lateral pressure simultaneously exerted on both sides of the bone. The fragments are so much splintered that in this way I have often found it easy to secure a pretty satisfactory impaction with no other force than the hands, and have, at the same time, reduced the prominence of the outer surface of the bone almost to the normal plane. More often it is necessary to lay the foot on its inner side, on a firm sand-bag (Fig. 1163), and reimpact the fragments with a heavy mallet, using a folded felt pad to protect the skin and to make sure against striking the external malleolus.

When the reduction has been accomplished, the foot is put up in plaster in slight plantar flexion with a "saddle" pad of felt about the top of the heel, and a sheet of felt across the dorsum of the foot. As

Fig. 1160.—Fracture of the os calcis; irregular fracture lines—outlines reinforced at one point.

Fig. 1161.—x-ray from sound foot of same case as shown in Fig. 1160; essential for comparison in many cases, not only for diagnosis, but for appreciation of amount of displacement and the necessity of operative interference.

the plaster sets, traction downward is made on the heel, while the position of the foot is secured by pressing down on the dorsum and molding the plaster upward to fit the arch of the foot.

Curiously enough, cases so treated never show any considerable painful reaction, and rarely even any increase in swelling.

The only danger is that of making the fracture compound, and that is a theoretic possibility: it has never happened yet.

The improvement in position is very satisfactory indeed.

Union in these cases is very prompt. After a week the fragments are immovable, and after three weeks there seems to be no giving, even under weight. I have, however, felt that at least a month should be allowed before putting weight upon the foot, and an even longer time if both heels have been broken.

Not later than ten days from the time of the reduction the plaster

should be cut and *active motion* of the foot allowed and encouraged for certain periods in the day, the cut plaster being reapplied in the intervals.

As to the time after the accident best suited to the reduction, there need be no rules, because the hemorrhage and the primary reaction in these fractures are comparatively slight, and the reaction after reduction is almost nothing. Even if we use the spindle in front of the Achilles tendon to aid reduction, the fracture is not thereby made compound, and we run no additional risk.

Fig. 1162.—Insertion of spindle in front of tendo Achillis to give traction on bone fragments when needed.

Treatment of Fracture of the Avulsion Type or of Transverse Fracture.—Here the deformity is one of upward displacement *only*, maintained by the pull of the heel-cord. Therefore treatment must be in plantar flexion or by tenotomy of the tendon.* Simple replacement and holding with pads has been tried: open operation is the alternative.

Tenotomy *and* fixation by a temporary nailing seems to be the rational combination.

Results in any case seem to be good.

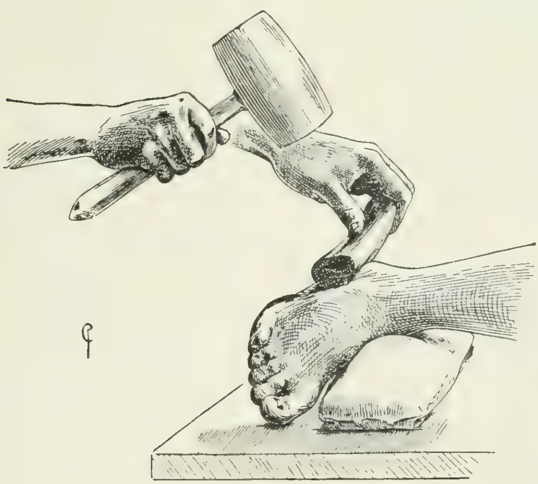

Fig. 1163.—Treatment by impaction. The foot is laid on a sand-bag, a felt pad held to protect the outer side of the os calcis, which is then impacted by blows from the mallet.

Compound Fractures of the Os Calcis.—These are, fortunately, rare, but occur as—(*a*) ordinary compound fractures from the accident;

* Tenotomy of the tendo Achillis is a matter of no risk or disadvantage. If the tendon is cut within an inch of its insertion, there is no tendency to great retraction (there is no tendon-sheath), and in three weeks' time we have a fairly strong new tendon.

(*b*) as secondarily open fractures exposed by sloughing of the skin. Owing to the comminution, the prognosis of either type is bad.

I have seen two of type *a*, with one amputation and one case apparently healing well when seen, and two of type *b*, of which one came to amputation for active sepsis and one lost most of the calcis by necrosis, but after many months got a foot on which he walks after a fashion, with fair reproduction of bone by the periosteum.

Results.—The results of these fractures when treated by ordinary conservative methods are often very unsatisfactory. I have taken pains to look up a good many of these cases. Some, perhaps a half, have serviceable though not normal feet, but a surprising proportion are more or less crippled, and the disability is not one that will improve with time. The causes of disability are:

(*a*) Loss of arch of the foot, resulting in pressure on the structures of the sole.

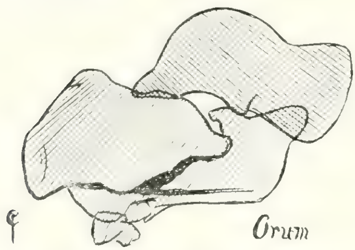

Fig. 1164. Small fragment projecting into the sole, sure to give trouble; readily removable.

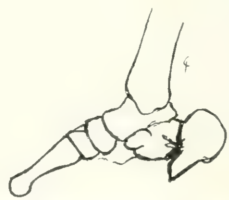

Fig. 1165. Projection of a fragment downward; most often the sharp anterior end of the posterior fragment gives a pressure-point in the heel that makes walking practically impossible (diagram).

(*b*) Loss of the arch with projection of fragments into the sole (Figs. 1164 and 1165), giving unbearable tenderness of the heel.

(*c*) Outward deviation of the heel, with secondary *static* flat-foot (Fig. 1167).

(*d*) Simple flat-foot from weakness of ligament, etc.

(*e*) Pain from pressure of the external malleolus against the thickened outer side of the os calcis (Fig. 1169). This corresponds exactly with the similar pain from pressure associated with exaggerated flat-foot, where the external malleolus touches the os calcis

(*f*) Loss of motion of the foot in pronation and supination, due to damage in or near the posterior joint between astragalus and os calcis.

These causes of disability may naturally be variously combined in the single case.

The projection of fragments into the sole of the foot may be dealt with by operation, with removal of such fragments. Pressure on the structures of the sole, due to simple loss of the arch, cannot be remedied in this way, but may be alleviated by wearing in the shoe a thick pad

of felt *under the heel itself* (Fig. 1166). Outward deviation of the heel with the flat-foot resulting cannot be relieved in most cases by the use of any plate or support. All that can be done is to resort to Gleich's operation (devised for flat-foot), which consists in cutting across the os calcis at its neck, and shifting the posterior portion down and inward. (See Fig. 1168.) This I have done in one case, with considerable improvement, but it is an undesirably extensive operation.

Fig. 1166.—Where there has been a good deal of upward displacement of the heel, direct bony pressure on the nerves and other soft parts in the arch may give pain. This is, in part, relievable by building up a support under the heel, thereby relieving the arch from pressure.

Pain from pressure of the external malleolus may be relieved by chiseling out the major portion of the bony projection which is in the way (Fig. 1169). There is little tendency, it seems, to reformation of this bone. This operation also I have done but twice, and am not ready to generalize, though the result in these cases was good.

Loss of motion in the foot may be somewhat improved by forcible correction under ether, but inasmuch as it is partly due to limitation from fracture into the joint, partly to shortening of muscles and tendons, the improvement to be gained is limited if this measure is postponed until after the fracture is united.

It will be seen, from what has been stated, that this fracture is one

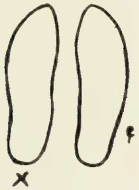

Fig. 1167.—There may be an *outward* deviation of the heel, sufficient to determine much trouble from static flat-foot. Unfortunately, inasmuch as the point of support is changed, these cases are very difficult to relieve with plates. The tracing of the foot to the left (see the cross) shows the outward twist of the foot in these cases.

Fig. 1168.—Gleich's operation for flat-foot; applicable to flat-foot from os calcis fracture. The os calcis is completely sawed across (best with a Gigli saw), and the heel portion carried forward and inward as far as we wish, and pegged or otherwise fastened into place.

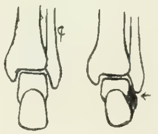

Fig. 1169.—The loosening of the outer plate with the thickening from callus is apt to give a thickening of the bone against which the external malleolus comes in contact, giving a point of very painful pressure.

which, in my belief, has been somewhat neglected, and in which it is possible, by careful treatment based on study of the individual case, to obtain much better results than the very unsatisfactory ones which now so frequently result from this injury.

For the sake of completeness it may be well to note that Ekehorn (Nord. Med. Ark., Stockholm, 1904, iv, Afd. I, No. 15) reported an "isolated luxation of the calcaneum." This article I have not been able to obtain.

CHAPTER XXXIII

OTHER TARSAL LESIONS

LUXATION OF THE CUBOID BONE

Isolated luxation of the cuboid is recorded. The luxation may be up, down, or outward. Partial luxations of the cuboid on the os calcis without other injury are on record (Bähr). More usually such subluxation is only part of a mediotarsal displacement, a displacement in this case rotatory, for the cuboid is here the axis, so to speak, of a twisting luxation. (See Fig. 1121.)

Except where the luxation is part of the mediotarsal lesion and is reduced with it, our obvious means of reduction will be by traction and *ad*duction of the front part of the foot, combined with appropriate direct pressure. If this measure, with rockings and rotations, fails, our recourse must be open reduction, and, failing in that, resection of the cuboid.

Fig. 1170.—Fracture of the cuboid by crushing. Little displacement.

Nothing especial is to be said about later treatment, or, so far as the data go, about results.

FRACTURE OF THE CUBOID

This results apparently only from crushing injuries; it is, therefore, likely to be a comminuted fracture, and may be compound. There is not apt to be any great displacement unless there are luxations or fractures of other bones of the tarsus associated with this fracture.

Diagnosis is made by signs of localized injury, by crepitus (crepitus here and in other tarsal injuries is often enough not obtainable where we might reasonably expect it), and, most definitely, by the skiagraph.

Treatment.—Save for general restoration of the outlines of the foot we can do nothing to improve position. The foot may best be put up in a plaster-of-Paris dressing reaching from the ball of the foot to just below the knee. Consolidation is prompt. Unless associated injuries of soft parts, etc., are severe, passive motion may be allowed at three weeks; weight-bearing may be begun to some degree at four or five weeks after the injury.

Prognosis.—So far as we have any data, no especial disability attaches to this lesion. Naturally, some lameness persists for a time and there is some tendency to pronation of the foot, to be guarded against as in all injuries in this region.

LUXATION OF THE CUNEIFORMS

Luxations of the cuneiform bones as a group, or singly, upward or downward, with or without displacement of the corresponding metatar-

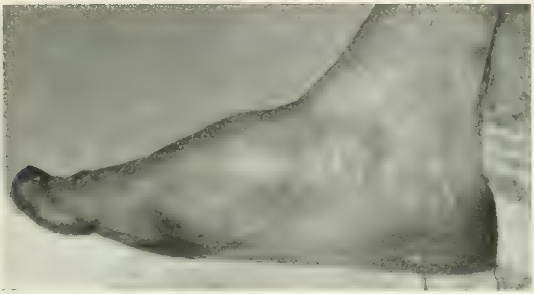

Fig. 1171.—Dislocation upward and backward of the cuneiforms on the scaphoid (reduced by Dr. A. Fraser, House Surgeon, City Hospital, Boston).

sal or metatarsals, do occasionally occur. The causes are not clear. The trauma usually seems disproportionately slight. Diagnosis depends on direct examination.

Reduction is by traction and pressure. Reduction of a bone dis-

Fig. 1172.—Old fracture of scaphoid and cuneiform, with some loss of bone; entire loss of arch; much disability. Note the shortening of interval between the base of the metatarsal and head of the astragalus; also the complete flattening of the arch.

located *singly* obviously presents the greatest difficulty; reduction may, indeed, be inpracticable; if so, and if the displaced bone is prominent, it may be well to excise it. Apparently the loss of even the first cuneiform is not a very serious matter.

After-treatment. Fixation for three weeks to six weeks, according to the severity of injury.

Prognosis.—Good—with the usual reservation as to necessary precautions in regard to pronation that apply to all tarsal injuries. Prognosis must take large account of *associated* injuries.

FRACTURE OF CUNEIFORM BONES

These fractures are rare; they occur as a result of complicated smashing injury of the foot.

Diagnosis.—Inferentially made on the basis of disturbed relation of landmarks; definite diagnosis impossible save by x-ray.

Treatment.—Restoration of the general contour of the foot—restoration (as nearly as may be) of the relations between landmarks; there are no definite schemes of manipulation.

Prognosis.—The prognosis is essentially that pertaining, in general, to crushing injuries of the foot, provided a reasonably accurate readjustment has been made.

Fig. 1173.—Fracture of the upper portion of the scaphoid, with comminution of the fragments.

OTHER FRACTURES OF THE TARSUS

Other fractures of the tarsus may occur (usually from direct smashing), but are so rare and so obscure that we have no accurate knowledge of them save as operation or the skiagraph furnish us information. Ordinarily, the lesions are multiple. Such fractures are not rarely compound.

Fortunately, the displacement is apt to be slight, and the treatment called for is only routine fixation, with mobilization not too long delayed.

Substantially the presence of fracture or its absence does not obviously affect treatment or prognosis in the crushing injuries of the foot in which such fractures occur. Failure to recover complete function is not uncommon and occurs at times even when no skeletal damage can be made out: the crushing of soft parts seems the important factor.

CHAPTER XXXIV

METATARSALS

DISLOCATION

The metatarsals, as a whole row, may not uncommonly be dislocated *upward* on cuneiforms and cuboid. Dislocation in other directions is rare. The lesion commonly occurs from apparently slight trauma—a misstep in stepping on a curbing, a slight unexpected fall on the ball of the foot, entanglement of the foot in a stirrup, etc. It may, of course, result from severer trauma, in twists of the foot caught in machinery, etc.

Diagnosis presents the only difficulty.

The foot is naturally swollen, and the deformity produced is unbelievably slight.

Accurate examination of landmarks should give the diagnosis.

Fig. 1174.—Backward dislocation of first metatarsal; fracture luxation of the outer cuneiform. Sketch from case of the author's.

There is some shortening of the foot, measured from tips of toes to convexity of heel—this will rarely be over $\frac{1}{2}$ to $\frac{3}{4}$ inch.

Pressure on the metatarsals in the "ball" of the foot (see Fig. 1188) in these cases, as in fractures, gives tenderness, but this does not help us in diagnosis of luxation *versus* fracture.

Reduction is by traction exerted in the direction of the long axis of the foot, combined with a rocking motion up and down, and direct pressure on the projecting bases of the metatarsal bones. There seem to be no cases of failure to reduce the luxation if diagnosis has been made.

After-treatment follows general lines.

Prognosis.—If the luxation has been reduced, there seems to be on especial disability associated with this lesion.

The prognosis is good despite the wide tearing of ligaments necessarily associated.

There seems to be no more tendency to flat-foot than with other

Fig. 1175.—Downward and backward dislocation of the first two metatarsals (outlines reinforced).

tarsal injuries. There may be some pain on *plantar flexion*, persisting for some time.

Even if the lesion is overlooked and unreduced on account of swelling,

Fig. 1176.—Same case as Fig. 1175.

the spontaneous restoration of function seems to be better than might be expected, though there is some deformity, some pronation, and an entire inability to rise on the toes or to exert a proper thrust with the front foot in walking.

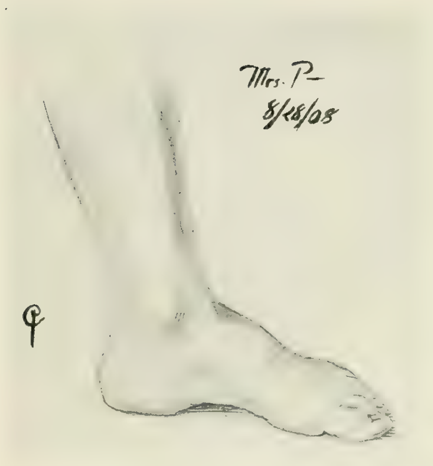

Fig. 1177.—Dislocation down and back of the first three metatarsals from the cuneiforms (old unreduced case; much disability).

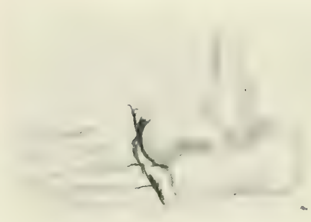

Fig. 1178.—Dislocation of metatarsals upward on cuneiform (old case; unreduced).

Fig. 1179.—Sketch of complicated luxation of metatarsus; amputated. Writer's case.

Fig. 1180.—Same case as in Fig. 1179, from in front.

Fig. 1181.—Same case as in Figs. 1179 and 1180, from the inner side.

Fig. 1182.—Same, dissected: *a*, Torn extensor minimi digiti; *b*, extensor communis; *c*, peroneus longus; *d*, torn end of peroneus tertius; *e*, nerve (saphenous); *f* and *f′*, cuboid (note crack on articular face); *g*, fourth metatarsal; *h*, third metatarsal; *i*, second metatarsal (with fracture of articular facet); *j*, second cuneiform; *k*, first cuneiform.

Fig. 1183.—Metatarsals dislocated up and back on the cuneiforms. Sketch after R. W. Smith's plate (same case as Fig. 1178).

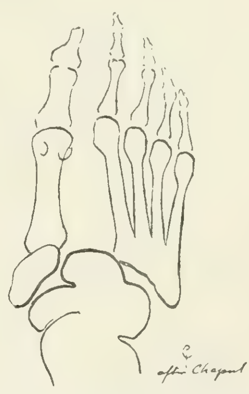

Fig. 1184.—Divergent luxation of the metatarsals.

METATARSALS—ISOLATED LUXATIONS

Any one or any group of the metatarsals may be luxated up or down. Isolated luxation occurs oftenest with the first.

Recognition of displacement must be made, in these cases, purely on localization of swelling and tenderness, on recognition of the bony deformity by touch, and by pressure on the ball of the foot (Fig. 1188).

Reduction is by traction and direct pressure. If this fails, we have no means of relief save recourse to incision and reduction of the displaced bone.

FRACTURE OF THE METATARSALS

Fracture of the metatarsals, save for the fifth, results from direct violence only: that is, from a weight falling or pressing on the foot—on the dorsum. So far as appears, impaction fractures analogous to those of the metacarpus do not occur. We may have fracture anywhere in the shaft of the metatarsals from the base down. Most commonly it is at or about the middle. Only rarely is it close to either end.

Fig. 1185. Fracture of the first four metatarsals (drawing from x-ray plate).

In one case (see Fig. 1186) have I seen separation of the proximal epiphysis of the first metatarsal.*

Very commonly more than one metatarsal is involved.†

As a rule, the fracture occurs toward the middle of the shaft.

Diagnosis.—Crushing injuries of the foot have certain peculiarities. *Irrespective* of bony damage, we find in these cases great swelling promptly following the accident, total disability, much pain, and tenderness. The swelling rapidly becomes so tense that we can feel nothing; the whole foot is so sensitive that any localized tenderness goes for nothing.

So far as direct examination goes, we have little to go on. Differential diagnosis as to which bone is involved is dependent on one sign only, namely, the presence of deep tenderness on pressure in the long axis of the bone. (See Fig. 1188.) This gives us some indication. Beyond this I must confess that I have usually found all signs useless.

* Note that *only* the first metacarpal has a *proximal* epiphysis.

† Curiously enough, there is an unexplained tendency to fracture of the second, third, or fourth metatarsal (especially the first two) in cases where the given history seems to point strongly to fracture of the first or fifth or of the whole row.

Here, more than in almost any region of the body, we are dependent on the *x*-ray for detailed diagnosis.

Treatment.—With the diagnosis once made, treatment must be directed toward the best possible reduction and fixation of the fragments,

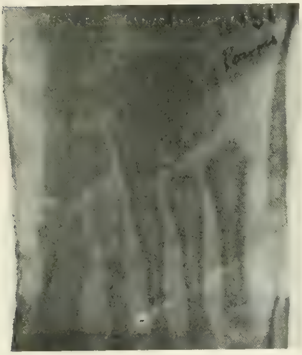

Fig. 1186.—Separation of epiphysis (reduced) of the base of the first metatarsal, proximal end. This was a separation with quite a little displacement before reduction.

Fig. 1187.—Fracture of the first metatarsal.

but with particular attention to two factors—namely, projection on the dorsum and projection downward into the plantar structures.

Accurate reposition laterally is not very important, but if there is

Fig. 1188.—Pressure on the ball of the foot in the line of the metatarsals; localized pain elicited by pressure of this sort on the head of a single metatarsal is our best single sign of fracture where there is swelling.

a projection of either fragment *upward*, boot pressure is almost certain to make trouble, and any considerable projection downward on the plantar side is almost certain to cause permanent tenderness of a serious sort.

Our best guide here is the x-ray. Any displacement found to exist may be, and should be, reduced at once or even at the end of one or two weeks.

In general we may say that upward displacements are less serious and more likely to be recognized. Consequently our attention is directed to *downward* displacement.

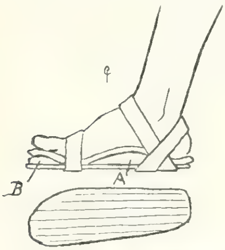

Fig. 1189.—Plantar splint; cut to the shape of the sole, as shown in the lower sketch; applied as shown in the upper sketch. Note position and direction of adhesive straps. There should be special padding, preferably of felt, at *A*, to preserve the curve of the arch; at *B*, to maintain a comfortable position of the toes (the toes are not comfortable when held straight out).

In default of exact data we are safe in putting up such a case in plaster, or, still better, in a plantar splint with felt padding (Fig. 1189), in such fashion that the arch of the bone is not only restored, but perhaps slightly exaggerated.

After-treatment.—Metatarsal bones carry a good deal of strain and, except in cases where the first metatarsal is not involved, fixation and rest is in order for not less than five weeks, followed by massage, passive motion, and gradual use.

Prognosis.—Properly handled, fractures of the metatarsals leave no disability of consequence unless there has been much damage to the soft parts.

Fractures healed with upward displacement are apt to give a good deal of trouble from friction of shoes.

A loss of the convexity of the bone gives some static disturbance, and is apt, according to its degree, and according to the bone involved,* to conduce to the occurrence of flat-foot.

Projection of either fragment into the sole gives pressure either on the nerves or on the other soft parts, and is apt to give a good deal

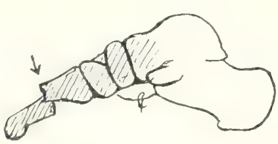

Fig. 1190.—Displacement of the sort shown in the sketch is apt to give trouble from friction of the shoe.

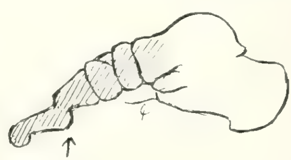

Fig. 1191.—The same displacement may give trouble from pressure in the sole, from pinching nerves or other soft parts between the projection of the fragment and the sole of the boot.

of disturbance. This may be relievable by pads that distribute the weight, or a late operation may be called for—a removal of the projecting spur.

* Anatomically, according to von Meyer and others, the second and third metacarpals carry the strain of the arch. In fact, clinically, it seems to be the first metacarpal that is peculiarly important for the preservation of this arch.

FRACTURE OF THE FIFTH METATARSAL

This bone may, of course, be broken by smashing, but there is a

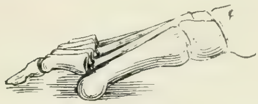

Fig. 1192.—Luxation backward of phalanges of all toes, as a row (schematic).

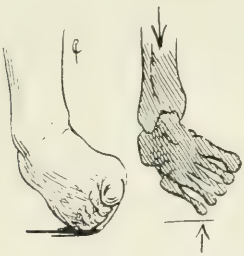

Fig. 1193.—Mechanism of fracture of the fifth metatarsal at the base. If the body-weight is received on the outer side of the foot, well out toward the toes, the strain comes on the fifth metatarsal; the base of this metatarsal is held by very solid ligaments to the base of the fourth metatarsal; therefore any lateral strain transmitted through the shaft will break the bone at or near the end of this fixed portion. Fractures of this sort are common and often overlooked.

Fig. 1194.—Pressure for diagnosis of fracture of the fifth metatarsal. On lateral pressure, as shown, localized tenderness is developed at point shown by cross; this is definitely diagnostic. Local tenderness may be very slight; lameness, only moderate.

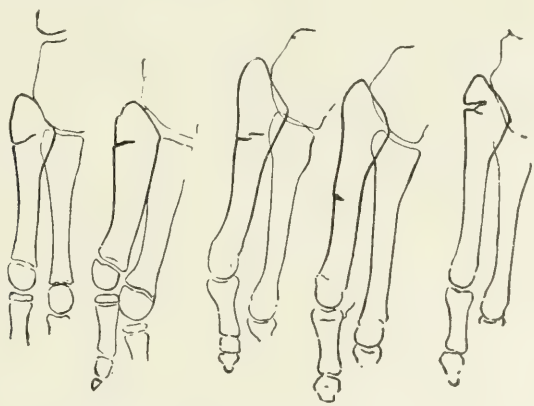

Fig. 1195.—Tracings from *x*-ray negatives: author's cases.

fracture peculiar to it—peculiar in both cause and character,—namely, the fracture of the fifth metatarsal *by inversion.*

Apparently never recognized previous to Jones' description in 1902,*

* Robert Jones, Ann. Surg., 1902, vol. xxxv, p. 697.

it seems none the less to be relatively common. I reported cases in 1903,* and Brickner† and others have added to the list.

The fracture is a pure inversion fracture, caused by treading on the outer side of the foot. Usually such turning of the foot is due to a slight

Fig. 1196. Fracture of fifth metatarsal by inversion (courtesy of Dr. E. H. Nichols).

Fig. 1197.—Fracture of the fifth metatarsal by inversion (author's case).

miscalculation of the ground level or to a misstep. In one of my cases the patient, a woman, slightly turned her ankle in dancing. The force producing the injury is usually slight.‡ The mechanism is obviously a sharp adduction of the front end of the metatarsal bone, bringing a cross-strain to bear just in front of the broad basal portion of the

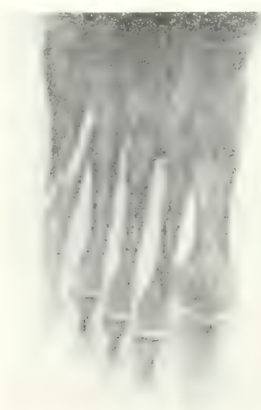

Fig. 1198.—Oblique fracture of fifth metatarsal, from inversion of foot.

* Cotton and Sylvester, Boston Med. and Surg. Jour., 1903, cxlix, 735; and Cotton, ibid., 1906, clv, p. 229.

† Brickner, American Jour. of Surg., Oct., 1906.

‡ The case of Fig. 1120 (Hoolihan) showed a similar lesion complicating a mediotarsal luxation, due to similar but severer force.

bone, which is held firmly appressed to the similarly broad base of the fourth metatarsal by very strong ligaments. Near the front of the broad base the metatarsal gives way. There may be a fissure of the outer side only, or a clean break across. The site varies somewhat, as shown by the tracings appended.

The pain is not great, and the immediate disability is only partial. All the cases I have seen have been assumed to be a sprain of the ankle, and the patient has walked more or less after the injury. Naturally the foot grows worse with use.

Diagnosis is dependent on localization of tenderness, slight local swelling, tenderness at the base of the bone on inward pressure at the *distal* end (Fig. 1194), and confirmation (not absolutely necessary) by the x-ray.

Treatment consists in the application of an arch-pad of felt with firm strapping of the foot—there is no deformity to reduce. Absolute rest for seven to ten days, with careful use thereafter under protection of pads and strapping, gives good results with no unpleasant sequelæ.

CHAPTER XXXV

THE PHALANGES

LUXATION OF THE TOES

Luxation of the toes is common enough, and not very important if recognized.

Most important is the displacement of the great toe, occurring most often as an upward displacement of the distal phalanx. Fig. 1199 shows the lesion and the deformity; here, as also with dislocation of the

Fig. 1199.—Dislocation backward of first phalanx of great toe of right foot (drawn from a case of the author's). Below, diagram of displacement. Arrows show lines of traction in reduction. It is to be noted in this case, as in all luxations about the toes, that the apparent displacement is slight—less than would be looked for.

proximal phalanges on the metatarsals, the deformity is less than we would expect.

Not rarely more than one toe is dislocated; at times the whole row of five toes may be luxated from the corresponding metatarsals (Fig. 1192).

Displacement may be of the distal bone up or down, oftener up; rarely we see lateral luxation or oftener subluxation.

Diagnosis depends on the obvious disturbance of relations as compared with those of the sound foot, more particularly in regard to shortening, which is invariably present in all these luxations. The lack of crepitus, the difficulty of reduction, the lack of tendency to recur, speak against fracture.

Reduction is by traction, with a rocking motion and with direct pressure. In backward luxations hyperextension with downward push may be called for. There are no especial obstacles met with in luxation of the toes like those opposing reduction of luxations in the hand.

Prognosis is good if displacements are reduced.

Fig. 1200.—Thumb and finger grip for reduction of phalangeal dislocations.

Fig. 1201.—Fracture of the proximal phalanx of the fifth toe.

FRACTURE OF THE TOES

Fracture of the toes is common enough, and results usually from direct violence. The only trauma that we may classify as indirect violence is that in which the toe is struck on the end or spread away from its fellow. Such injuries occur to the bare foot only, usually from "stubbing" the toes against a chair or bed in a dark room at night. Either fracture or luxation may result.

The common fracture is from crushing.

Any phalanx may be broken. Swelling is prompt, and the signs of crushing are apt to mask the fracture. Even with crushing, *comminuted* fracture is the exception.

If the great toe is involved, we not rarely have compound fracture—compound on the dorsum.

Compound fracture of other toes is unusual.

Diagnosis is by abnormal mobility and crepitus.

Treatment.—Immobilization is all that is needed save in compound cases.

Ordinarily, there is no tendency to displacement—a plantar splint is enough.

Results.—No serious result is to be apprehended. The usual trouble is tenderness and inability to wear a shoe, even for some time after union is firm, on account of thickening and soreness.

End-results are uniformly good, even if there is some deformity.

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